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(February 1941)

The Editorial Committee of the Imperial Council of Agricultural Research, India, takes no responsibility for the opinions expressed in this Journal.

ORIGINAL ARTICLES

*FLOATING HABIT IN RICE

BY

K. RAMIAH

Formerly Paddy Specialist, Coimbatore

AND

K. RAMASWAMI

Paddy Assistant, Coimbatore

(Received for publication on 18 January 1940)

(With Plates I and II)

Introduction

AMONG the thousands of rice varieties cultivated in India and Burma there is a particular class known as deep-water rices which is chiefly to be found in Bengal, Assam and Burma. In the tracts where these rices are grown, they are usually sown broadcast during March-May and harvested in December-January. With the onset of the monsoon in June, the areas where the rices are grown are flooded. The water rises gradually in the fields, reaching to a height of even 20 ft. in some cases. The rice grown under such conditions has to keep pace with the water rise, and this it generally does, when the latter is gradual and not too rapid or sudden. Botanical study of the deep-water rices has not been made for a long time because of the inherent difficulties. Recently, however, a special research station for such study has been opened at Habiganj, Assam, financed by the Imperial Council of Agricultural Research.

The typical deep-water conditions, such as those existing in Bengal and Assam, are not present in Madras. In some places, however, the water accumulates to depths of more than 5-6 ft., but this condition does not persist for a sufficiently long time. By experience the cultivators have found that some of the ordinary varieties are able to stand this moderate and temporary flooding. *Akkullu* of the Godavari, *vadansamba* of Tanjore and *kuttadan* of Malabar are some of the varieties cultivated by ryots under these conditions. The maximum height to which these varieties are known to grow is about 8·10 ft. whereas the senior author of this paper has seen the typical deep-water rice growing to a height of even 20 ft. in Habiganj (Plate I, fig. 1). Certain of the deep-water rices of Bengal were introduced in Madras some years ago for trial. These are now included in the type collections of the Paddy Breeding Station, Coimbatore. The present paper deals with the genetic investigations with one of these types, T 599, started in 1933.

Characteristics of deep-water rices

The main difference among the several deep-water rices grown in Assam is their differential response to varying depths of water [Majid, 1936]. Presumably, associated with their deep-water habit are some morphological

*Paper contributed to the Indian Science Congress, 1937

differences which are characteristic of these rices. The stems do not grow quite erect but rather zig-zag under the water and have a tendency to crawl on the surface above the water level, and this peculiar habit is responsible for their being called ' floating rices '. Very often tillers and roots are produced at the nodes higher up from the base of the stem (Plate I, fig. 2). Though these characters are pronounced only when the deep-water conditions are present, they can still be made out when grown under less suitable conditions, where there is not sufficient water to support the growing shoots, in which case they come down flat on the ground, particularly at the later stages. One special characteristic of the deep-water rices observed in Coimbatore is their rate of growth, which is comparatively greater than that of ordinary rices, due evidently to their inherent tendency to keep pace with the rapid rise in the water level obtaining in their natural habitat. Among hundreds of varieties grown side by side in the seed-beds at the Paddy Breeding Station, Coimbatore, it is always an easy matter to pick out the deep-water rices by their taller growth (Plate I, fig. 3). The growth of these seedlings is fairly rapid for some time after transplantation and it gradually slows down later in the absence of sufficient depths of water. The increase in height after transplanting is brought about mainly by the elongation of the internodes close to the ground. A similar response is shown even by ordinary rices which, under conditions of high initial fertility in the soil, elongate their lower internodes more than under normal conditions, resulting in premature lodging [Ramiah *et al.*, 1934]. The root-system of the deep-water rice has been found to be not as well developed as in ordinary rices of similar duration. Under the flooded conditions the lack of an efficient root-system is probably made up by the roots formed at the higher nodes, which according to Majid [1936] do supplement the normal roots in the supply of nutrition to the plant.

In Coimbatore these rices are first sown in seed-beds and later transplanted, as in the case of ordinary rices, but the *bunds* of the fields in which they are planted are specially raised to impound more water than is usual, say, up to two feet. Even under such conditions, which are not anything like what occur in Assam or Bengal, the special characteristics of the deep-water rices become apparent, sufficient to distinguish them from the rest.

Material for the study

One of the deep-water rices, T 599, which has been grown in Coimbatore for some years and found to be pure for the characteristic habit, was crossed with an ordinary type, T 300, with a typical compact habit of growth (Plate II, fig. 1). T 599, though normally grown under ordinary conditions as those for other rices at the Paddy Breeding Station, nevertheless shows its capacity to respond to deep-water conditions when such are provided. Potted plants were suspended under water in a well and the depth of water gradually increased, when it was found that the plants grew up with the rise in water level and reached nearly 12 ft., in contrast to the maximum height of only 5 or 6 ft. obtained when planted under ordinary field conditions. This characteristic response of deep-water rice could not be made use of for differentiating deep-water and ordinary rice in our study of the hybrid between these types

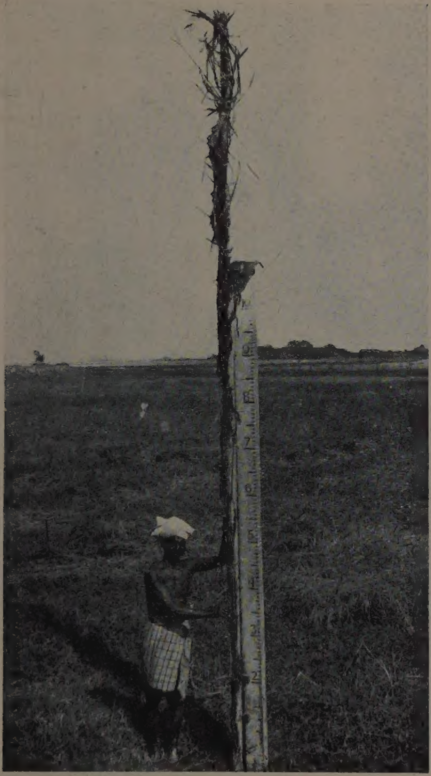

FIG. 1. A typical floating rice plant grown in Habiganj, Assam

FIG. 2. A plant of T 599 showing tillering and rooting

FIG. 3. Seedlings of T 300 and T 599—three weeks old

Fig. 1. Typical plants of T 599 and T 300

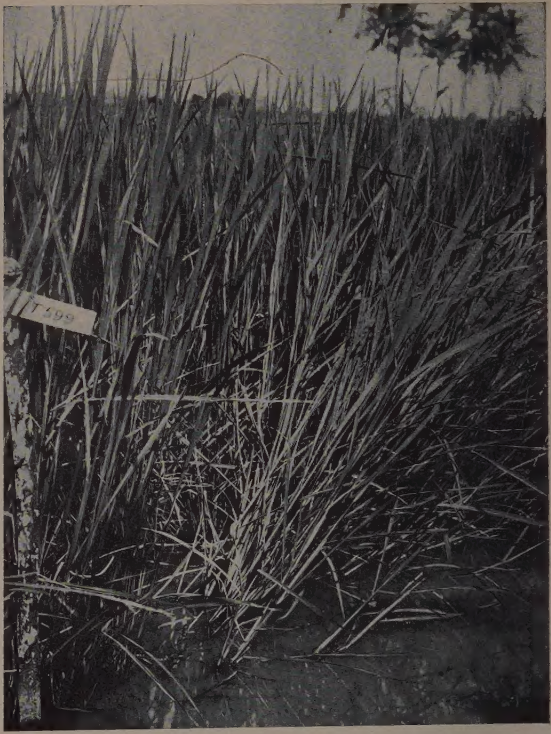

Fig. 2. T 599, just before flowering phase

and its progenies as it was found impossible to provide the deep-water conditions artificially at Coimbatore. However, other characters which will be described later, typically distinguishing the two types, were employed for the study of the F_1 and later populations.

F_1 AND F_2 CHARACTERS

According to the usual practice adopted in Coimbatore, the hybrid seeds along with the parents were first sown in seed-pans and the seedlings later transplanted in a field, with the parents on either side of the hybrid. The F_1 characters in comparison with those of the parents are given below :—

Type No.	Height of plant (ft.)	Flowering duration (days)	No. of ears* per plant	Habit
T 300 . . .	$3 \cdot 3 \pm 0 \cdot 06$	$95 \cdot 4 \pm 0 \cdot 46$	$37 \cdot 5 \pm 1 \cdot 18$	Normal, compact tillers
T 599 . . .	$5 \cdot 2 \pm 0 \cdot 06$	$103 \cdot 1 \pm 0 \cdot 25$	$27 \cdot 2 \pm 1 \cdot 42$	Floating, not compact
F_1 . . .	$4 \cdot 5 \pm 0 \cdot 04$	$105 \cdot 1 \pm 0 \cdot 34$	$31 \cdot 2 \pm 2 \cdot 10$	Normal

* The very large number of ears per plant is due to the wide spacing given per plant namely, 2 ft. × 2 ft.

The F_1 is more or less intermediate in height between the parents, the small increase over the mean of the parents being probably due to heterosis. In flowering duration, lateness of T 599 is apparently dominant. With regard to habit, the F_1 was normal, there being no indication of the floating habit at all even in the final stages. Though the plants were grown only under ordinary conditions, T 599 exhibited the characteristic floating habit just before the commencement of the flowering phase ; the tillers on the outer zones of each clump started trailing on the water surface and the whole plant showed a tendency to topple over (Plate II, fig. 2). At a still later stage all the tillers came down flat on the surface of the water level.

In 1935 an F_2 generation of about 440 plants was raised under ordinary conditions only. There was segregation for the floating habit (Plate II, fig. 3) and all the plants resembling T 599 were put into one class, grouping the rest as normal. The ratios obtained were :

	Normal habit	Floating habit	Total
Observed	412	28	440
Expected on a 15 : 1 ratio .	$411 \cdot 5$	$27 \cdot 5$	440

The floating habit is evidently controlled by duplicate recessive genes, **ef**$_1$ **ef**$_2$.

F_3 RESULTS

To make sure of the F_2 segregation for the floating habit, 10 rows of plants from the F_2 comprising about 190 plants were carried forward and the F_3 generation raised from them. Since the idea was only to confirm the F_2

ratios, the size of each of the F_3 families was restricted to 75 plants only. Except in certain of the families mentioned below no detailed counts were taken beyond recording whether each family was pure or segregating for the habit.

No. of F_3 families grown	F_2 character	F_3 behaviour
177 . . .	Normal habit .	82 pure normal habit (82·6), 95 segregating for habit (94·4) (Both 3 : 1 and 15 : 1 ratios)
14 . . .	Floating habit .	Pure floating

The expected pure and segregating families on the basis of duplicate factor hypothesis (figures in brackets) agree with the actuals closely. The ratios obtained in some of the segregating families where individual counts were taken are given below :—

Family No.	Normal habit	Floating habit
3157	58	16
3164	56	14
3176	49	23
3190	51	13
Total . . .	214	66
Expected on 3 : 1	210	70

Family No.	Normal habit	Floating habit
3156	68	4
3161	67	6
3169	61	4
3180	67	5
Total . . .	263	19
Expected on 15 : 1	264·4	17·6

Among the segregating F_3 families there are thus two kinds of segregation as would be expected, and the F_3 behaviour confirms the observations made in F_2.

Association of floating habit with other characters

Besides the observations for the floating habit for which the cross was mainly intended, the F_2 generation was also studied for various other characters as nature of tillering, flowering duration and plant height.

Nature of tillering.—Rice varieties vary very much in regard to their nature of tillering ; in some, the tillers remain erect and compact and in others they are spreading and open, the former being sometimes a simple recessive [Ramiah, 1930]. In the present cross, T 300 has a compact tillering while the floating rice T 599 has an open tillering. There was a clear segregation in the F_2 for this character and while the compact type was easily made out,

there was a good deal of variation among the open types. Actual counts of the two types gave 218 compacts to 218 of the rest. Evidently the segregation for this character is not simple in this cross. The classification of the F_2 for the nature of tillering along with the floating habit is given below :—

	Normal habit		Floating habit	
	Compact tillering	Rest	Compact tillering	Rest
	198	210	20	8
Expected on independence of the two characters	204	204	13·5	13·5

$\chi^2 = 6 \cdot 6$, P between 0·05 and 0·02

On a test of independence the deviation from the expected is definitely significant in the case of the floating group, i.e. a larger number of plants with the floating habit tends to be compact in tillering. It must be noted in this connection that there was no difficulty in distinguishing the habit, floating or normal, along with the nature of tillering, loose or compact. The nature of tillering can be identified even in the earlier stages as the plants grow, while the floating habit, under the conditions in which the plants were grown in Coimbatore, is best made out just when the plants are nearing shot-blade stage. At this time, in plants with the floating habit the outermost tillers in the clone begin to trail on the ground and later the whole plant leans out, the tillers not being able to stand erect. In the floating type the plant with the compact tillering leans out as a whole and all the tillers lie together, whereas in the plant with the loose tillering the leaning over of the tillers happens in all directions and they are thrown far apart, with the result that the plant presents an outspread appearance. In the plants with the normal habit the tillers may remain compact or open but they never trail on the ground and the plants do not get the tendency of falling over.

Plant height.—T 300 was short while T 599 was tall and the F_1 was more or less intermediate between the two. The F_2 was varying a great deal for plant height. Though actual measurements of individual plants were not taken, they were classified into three groups—tall, medium and short—by eye-judgment and the following ratios were obtained :—

Tall	Medium	Short	Total
187	199	52	438

The classification of height along with the habit gave :

Normal habit			Floating habit		
Tall	Medium	Short	Tall	Medium	Short
175	189	47	12	10	5
Expected on independence of the two characters :					
175·5	186·7	48·8	11·5	12·3	3·2

$\chi^2 = 1 \cdot 56$, P between 0·95 and 0·90

It shows that both the characters, plant height and plant habit, which are controlled by different mendelian genes are independent and there is no sort of interaction among them. The significance of this is discussed later.

Flowering duration.—T 599 was definitely later than T 300 and the F_1 was also showing complete dominance of lateness. The flowering dates of individual plants were noted every alternate day in the F_2 generation and the frequencies are given in the table below :—

Frequencies of flowering duration—days after sowing—in F_2

Days	70	72	74	76	78	80	82	84	86	88	90	92
Normal . .	10	9	14	23	13	5	3	4	7	1	0	4
Floating . . .	3	0	2	3	3	...	...	1	...	...	1	...
Total .	13	9	16	26	16	5	3	5	7	1	1	4

Days	94	96	98	100	102	104	106	108	110	112	114	Total
Normal . . .	11	47	12	82	64	47	39	7	8	0	2	412
Floating . . .	1	1	1	6	1	3	...	...	1	1	...	28
Total .	12	48	13	88	65	50	39	7	9	1	2	440

If the frequencies are divided at the minimum frequency point, say, 90 days, and totalled, we get :

	Early	Late	Total
	102	338	440
Expected 1 : 3 ratio	110	330	440

$\chi^2 = 0 \cdot 773$, P between $0 \cdot 7$ and $0 \cdot 8$

Evidently lateness here is a simple dominant to earliness. The distribution of the earlies and lates is, however, not the same in the two groups, normal and floating habit. There is an excess of earlies in the floating group. Applying the test of independence, we get $\chi^2 = 9 \cdot 08$ and P less than $0 \cdot 01$, which means that the two characters, flowering duration and habit, are not genetically indepdendent.

	Normal habit		Floating habit		Total
	Late	Early	Late	Early	
	323	89	15	13	440
Expected on 45 : 15 : 3 : 1 ratio	309·4	103·1	20·6	6·9	440

Evidently one of the genes controlling habit and the gene controlling flowering duration are linked and there is crossing-over to the extent of 30 per cent calculated by the ' maximum likelihood ' method. Which of the duplicate genes for habit is linked with duration gene has to be investigated.

Discussion

The investigation here recorded definitely proves that the floating habit, characteristic of one of the deep-water rices grown extensively in Bengal and Assam, is a mendelian recessive controlled by two duplicate genes. The detailed examination of the F_2 of a cross between a floating rice and a normal rice for some of the other important characters besides the habit has shown some interesting genetic associations which are of great significance in practical breeding. A rice with a compact nature of tillering is always to be preferred to those with an open, loose type of tillering, as the former does not usually lodge at the time of harvest to the same extent as the latter. Although the question of lodging of the straw is not an important consideration in the case of the floating rices, it will still be an advantage to introduce the compact nature of tillering in them by suitable crosses. This might facilitate ease in harvest and it is possible that with a compact nature of tillering a larger number of seedlings can be planted per acre and this should materially add to the final yield.

Among the deep-water rices in Bengal and Assam there are different types suited to the different depths to which the water is expected to rise. This, in all probability, is mainly a question of the height (a mendelian character) up to which the plant is capable of growing. Since this investigation has shown that there is no genetic association between plant height and the floating habit, it should be a simple matter to breed out floating types of different heights by suitable crossings with rices of normal habit. One of the complaints in certain parts of Madras, where there is scarcity of fodder, is that some of the improved types recommended by the Agricultural Department do not produce enough straw. In the deltas where the rice fields are cultivated mostly by tenants for a portion of the produce, the tenants get only a small fraction of the grain but the bulk of the straw. It is by selling the surplus straw that the tenant can expect to get something out of the land and thus the quantity of straw produced per acre is certainly an important factor. Other things being equal a taller-growing rice should give more straw than a shorter one. The inherent nature of the more rapid growth of the floating rices can be made use of to increase the straw yield of the ordinary rices by suitable crosses. In fact some pure breeding types with longer straw and hence larger amount of straw than the parent T 300 have been extracted out of this cross. Wherever the yield of straw is sought to be increased in rice, the best way of doing it would appear to be to cross it with a floating rice and select suitable types from the F_2 onwards.

Though no detailed analysis was made of the F_2 with regard to the variations in grain size in this cross, the results would seem to indicate that the grain size, again a mendelian character, is independent of the floating habit. Floating rices are all generally coarse grained. Parent T 599 is also coarse, whereas T 300 is a fine grain. Pure-breeding fine rice types, like T 300, but with the floating habit have been extracted from this cross.

Lastly this cross has also shown the possibility of getting floating types with different flowering durations which is important economically. Though

the genes controlling flowering duration may be different in different rices, the results obtained from this cross indicating a linkage between duration and floating habit would appear to demonstrate the possibilities of breeding specially early types in floating rices by suitable crosses.

The few floating rices available in the Coimbatore collections have not shown much variation in their flowering duration. Moreover, unlike in their original home (Bengal), they are planted in Coimbatore much later in the season, July-August, instead of April-May and this should by itself reduce the duration considerably. Duration is controlled by several genes [Ramiah, 1933] and there must be a big variation in the flowering duration among the floating types cultivated in Bengal and Assam. It would be interesting to undertake crosses between a normal type and floating types of different durations to get more definite information on the genetic linkage of floating habit and duration.

A certain number of pure types have now been extracted from the homozygous F_3 families of this cross showing various combinations, like early and late, tall and short, open and compact tillering and coarse and fine grain with the normal and floating habit, types different from the two parents.

Summary

The habit of the deep-water rice designated ' floating habit ', though it develops properly only with deep-water conditions, can still be made out even under ordinary conditions. It grows much faster than rices of similar duration, particularly in the early stages, and at the later stages the whole plant leans over, the outer culms of the clump developing a tendency to sprawl on the water surface.

A cross between an ordinary rice and a rice with the floating habit has shown that the floating habit of the latter is controlled by duplicate recessive genes designated $\mathbf{ef}_1$ and $\mathbf{ef}_2$, the F_2 giving a 15 : 1 ratio of the normal to the floating habit.

The two parents differed in plant height, flowering duration and nature of tillering, and there was segregation for all these characters in the F_2. There was no genetic association between plant height and floating habit. With regard to flowering duration, however, lateness was a simple dominant to earliness, and the F_2 ratios would appear to indicate that the gene controlling duration in this case is linked with one of the genes controlling habit with about 30 per cent crossing-over.

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INHERITANCE OF EARLINESS IN SURMA VALLEY RICES

BY

H. K. NANDI, M.Sc., Ph.D., F.L.S., F.R.M.S.

Economic Botanist, Assam

AND

P. M. GANGULI

Botanical Assistant, Karimganj Paddy Farm

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(With six text-figures)

Introduction

THE groups to which rice belongs are generally termed summer, autumn-winter and spring rices, referring only to the period of harvest. Accord, ing to this convention the Surma Valley rices are classified as follows :

Summer rices—(Early *aus*)—*dumai*, *murali* and *chengri*
Autumn rices—*Aus*
Winter rices—*Sali*, *asra* and *aman*
Spring rices—*Boro*

Flowering duration is, therefore, an important physiological character which should be studied in all its bearing. Summer and autumn rices are time-fixed and the winter rices are season-fixed [Mitra, 1937]. The time and period of flowering varies slightly from year to year. The length of the growing period varies a good deal with the climatic conditions of the locality as is also shown by Thadani [1928]. Inheritance of the flowering character in rice is therefore a complicated subject, and various results were obtained at different places and with different varieties.

Hoshino [1915] found in a cross between early and late maturing rice that the time of flowering in F_1 was intermediate but nearer that of the early parent. The F_2 generation equalled the combined range of the parents. The author suggested that three multiple genes would explain the results.

Ikeno [1918] reported that in crosses of early and late rices the F_1 was intermediate and segregation in F_2 was complex and apparently due to multiple factor.

Hector [1922] found that the F_2 progeny from a cross between an autumn and a winter rice segregated into two distinct groups with respect to date of flowering. These two flowering periods were the same as the flowering dates of the two parents with an interval of about three weeks during which time no blooming occurred. The ratio of early to late was approximately 1 : 3.

Nomura and Yamazaki [1925] found that the F_1 hybrids were a few days later in shooting than the late parent and in F_2 segregation was in the ratio of about 3 late to 1 early with transgressive segregation on both sides. For interpretation, the authors drew up a trigenic basis.

Bhide [1926] observed the dominance of lateness in a monogenic ratio in certain crosses while in other crosses, however, such dominance of lateness over earliness was not very evident.

While studying the crosses from various early and late types in rice, Jones [1928] observed that the F_1 plants might be earlier than the early parent, later than the late parent or nearer the early or late parent in time of flowering. The F_2 plants studied could not be placed with any degree of certainty in any of the simple or modified ratios. Transgressive inheritance occurred and there was a heaping up of plants in the intermediate position in F_2. He finally observed that two or more genetic factors are involved in the production of earliness in the rices studied.

In the course of the investigations on the inheritance of flowering duration and height, Ramiah [1933] observed the simple dominance of earliness in one cross and the converse of it in another. Six more crosses were also tried by him from four extracted types obtained from the above two crosses and the results were explained both on a multiple-factor hypothesis and on an inhibitory factor hypothesis, although the former gave wider scope to account for the wider variability arising from a greater number of pheno-type combinations.

Crescini [1930], while studying the behaviour of the character of earliness in the F_2 crosses of *T. vulgare*, observed in one cross the complete dominance of lateness in a clear 3 : 1 ratio. While the curve of variability of the F_2 of another cross was clearly bimodal with an incomplete dominance to the earlier parent, the curve for the F_2 of the third cross was also bi-modal but intermediate between the parents. The F_2 of the fourth cross was also intermediate and showed a marked transgression to the later parent.

Breeding by use of transgressive segregation, Roemer [1933] obtained in spring barleys certain segregates which eared as much as 10 days earlier than the early parent.

From the results of a study of earliness in some *sathi* crosses Sethi [1938] observed that the frequency distribution of flowering duration in F_2 was continuous and extended from the lower extreme of the early parent to well beyond the upper extreme of the late parent.

EXPERIMENTS AND DISCUSSION

Several crosses were tried between summer, autumn and winter rices and the results dealt with separately in each case.

1. *Cross No. 1 (M 36-30 × As 15-5)*

The early parent M 36-30 took about 71 days and the late parent As 15-5 about 112 days from sowing to flowering with a difference of about 41 days between the two parents. The F_1 plants were more or less intermediate with a mean duration of 80 days inclined much towards the early parent. The range of variation in F_2 was from 70 to 165 days with a mean duration of about 93 days. The early plants in F_2 just reach the flowering range of the early parent while the late plants go much beyond the range of the late

parent, showing one-sided transgressive segregation. Fig. 1 shows the actual segregation of the F_2 progenies with a curve extending on one side and probably representing a multiple-factor hypothesis.

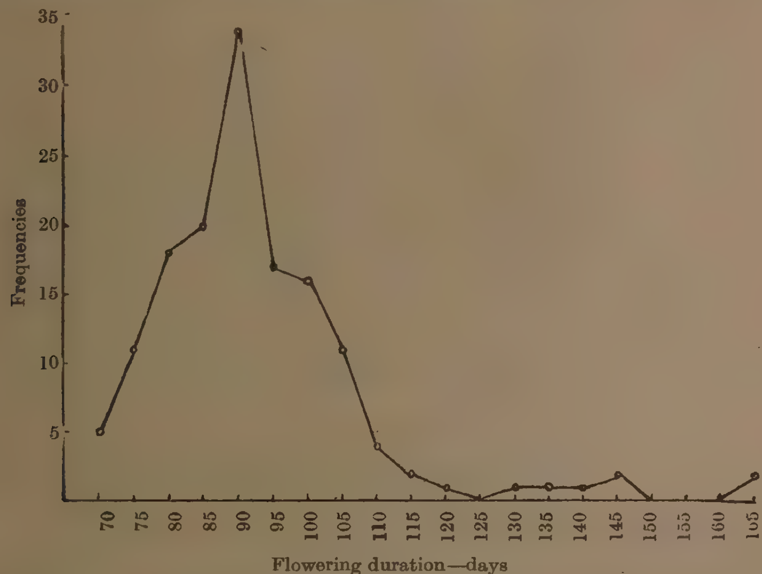

FIG. 1. Cross No. 1—F_2 generation

2. Cross No. 777 (D 138-6 × As 3)

One of the parents D 138-6 belongs to the earliest group, while the other parent As 3 is about 3 weeks later than the former. The flowering durations of the parent plants and the F_1 and F_2 plants are given below :—

	Range of variation in flowering (days)	Mean duration in flowering (days)
D 138-6	67—71	69
As 3	88—92	89
F_1	72—77	75
F_2	72—95	80

The above figures show that the F_1 plant is intermediate inclining towards the early parent. The F_2 plants segregate with a long range of variation. The early plants in F_2 just reach the flowering range of the early parent and do not overlap, while the late plants go slightly beyond the range of the late parent. Fig. 2 shows a normal curve indicating a multiple-factor hypothesis.

In F_3 some of the early and late plants bred true, while some segregated again into early and late.

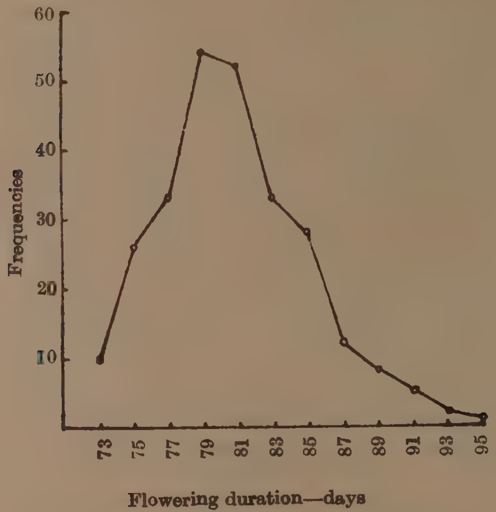

FIG. 2. Cross No. 777—F_2 generation

3. Cross No. 869 (As 3 × As 10)

The flowering durations of the parents and the F_1 and F_2 plants are shown below :—

	Range of variation in flowering (days)	Mean duration in flowering (days)
As 10	79—85	82
As 3	89—92	90
F_1	79—89	83
F_2	81—119	90

The above figures show that the F_1 plants are almost as early as the early parent. The F_2 plants have a wide range of variation just beginning with the early parent but going far beyond the late parent, i.e. the transgressive segregation is definitely one sided. Fig. 3 shows the segregation in F_2 with about a normal curve extending on one side and pointing to a multiple-factor hypothesis. In F_3 only a few of the early and late plants bred true while the majority segregated.

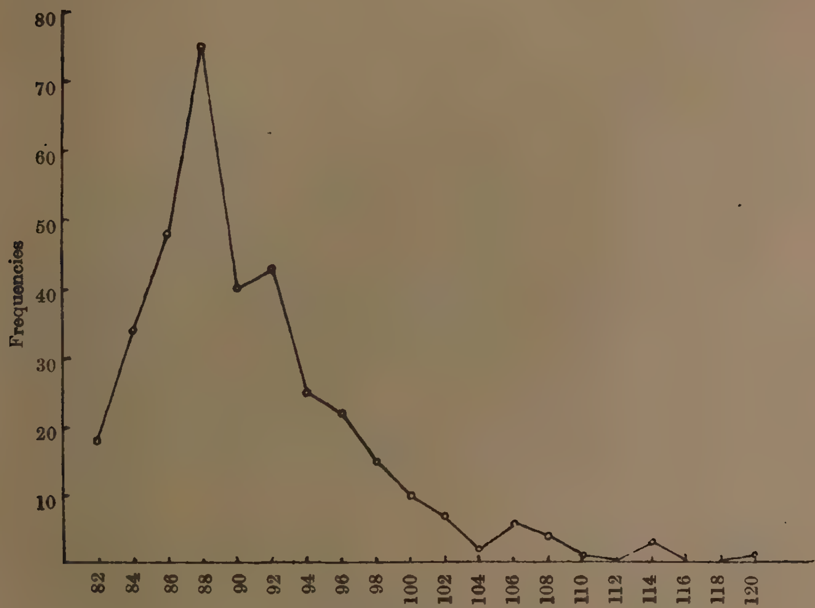

FIG. 3. Cross No. 869—F_2 generation

4. Cross No. 363 (M 36-30 × Ar 1)

This is a cross between a late summer and a winter paddy. The flowering durations of the parents and the F_1 and F_2 plants are shown below :—

	Range of variation in flowering (days)	Mean duration in flowering (days)
M 36—30	78—82	80
Ar 1	129—131	130
F_1	103—107	105
F_2	68—158	107

The above figures show that the F_1 is definitely intermediate, while F_2 has a wide range of variation beginning earlier than the early parent and finishing later than the late parent, i.e. unlike the previous crosses there is transgressive segregation on both sides. This may be explained on a duplicate factor hypothesis as done by Ramiah [1933].

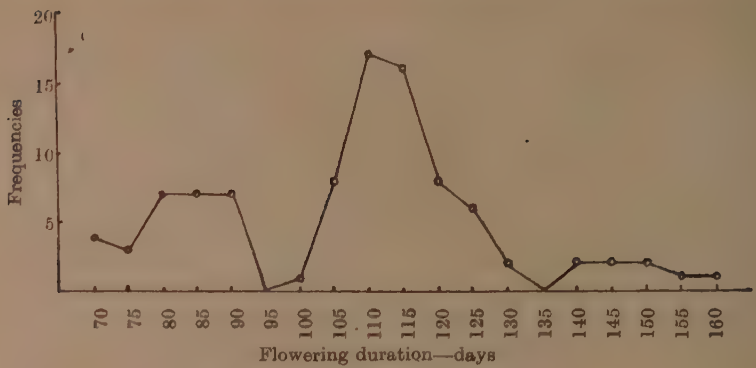

FIG. 4. Cross No. 363—F_2 generation

Fig. 4 shows graphically the segregation in F_2 with a bi-modal curve. There is a minimum frequency point at 95 days and the totals on either side of this give a clear ratio of 4 early : 12 late as shown below :—

Cross No. 363	Early	Late	Total
Observed	28	66	94
Calculated (4 : 12)	23·5	70·5	94

$\chi^2 = 1 \cdot 149$; $P = 0 \cdot 28$. The fit is fairly good.

5. Cross No. 546 (D 138-6 × Ar 1)

This is a cross between an early summer paddy and a winter paddy (the same as in the previous cross). The flowering durations of the parents and the F_1 and F_2 plants are shown below :—

	Range of variation in flowering (days)	Mean duration in flowering (days)
D 138—6	67—71	69
Ar 1	132—136	134
F_1	105—106	106
F_2	65—150	103

The above figures show that F_1 is definitely intermediate, while F_2 has a wide range of variation starting almost with early parent but finishing later than the late parent, i.e. the transgressive segregation here is rather one-sided. This may be explained on a triplicate-factor hypothesis supposing that the factor **E** makes the plant early and **L** makes the plant very late while **I**, an inhibitory factor, inhibits **L** and makes the plant somewhat earlier than the very late plant but later than the early plant. **E** is dominant over **L**. The

genetic constitution of the parents and the F_1 and the factorial analysis of the F_2 is given below :—

D 138—6	**EEiill**	Early
Ar 1	**eeIILL**	Late
F_1	**EeIiLl**	Early
F_2	**27 EIL**	,,
	9 EIl	,,
	9 EiL	,,
	9 eIL	Late
	3 eIl	,,
	3 eiL	Very late
	3 Eil	Early
	1 eil	Late

48 early : 16 late

Fig. 5 shows the segregation in F_2 with a bi-modal curve. The total frequencies on the two sides of the break give a ratio of 48 early to 16 late as shown below :—

Cross No. 546	Early	Late	Total
Observed	108	44	152
Calculated (48 : 16)	114	38	152

$\chi^2 = 1{\cdot}263$; $P = 0{\cdot}26$. The fit is fairly good.

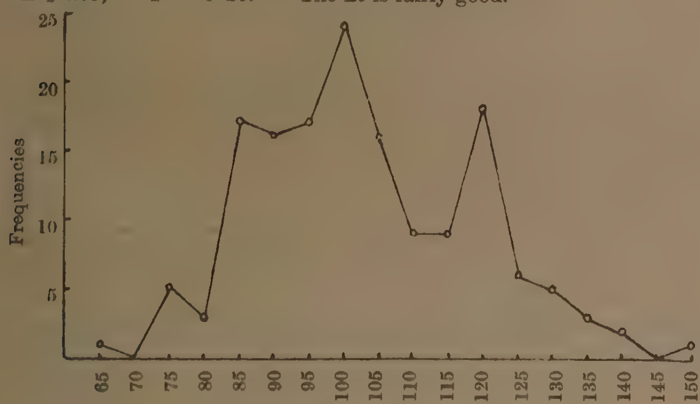

FIG. 5. Cross No. 546—F_2 generation

6. *Cross No. 1520* (*D 138-6 × S 22*)

This is another cross between an early summer paddy and a winter paddy. The flowering durations of the parents and the F_1 and F_2 plants are given below :—

	Range of variation in flowering (days)	Mean duration in flowering (days)
D 138—6	69—78	72
S 22	163—166	165
F_1	128—134	133
F_2	68—183	117

The above figures show that the F_1 is more or less intermediate, inclined much towards the late parent. The F_2 plants have a wide range of variation just beginning with the early parent but going far beyond the late parent, i.e. the transgressive segregation is definitely one-sided. Fig. 6 shows the segregation in F_2 with a bi-modal distribution.

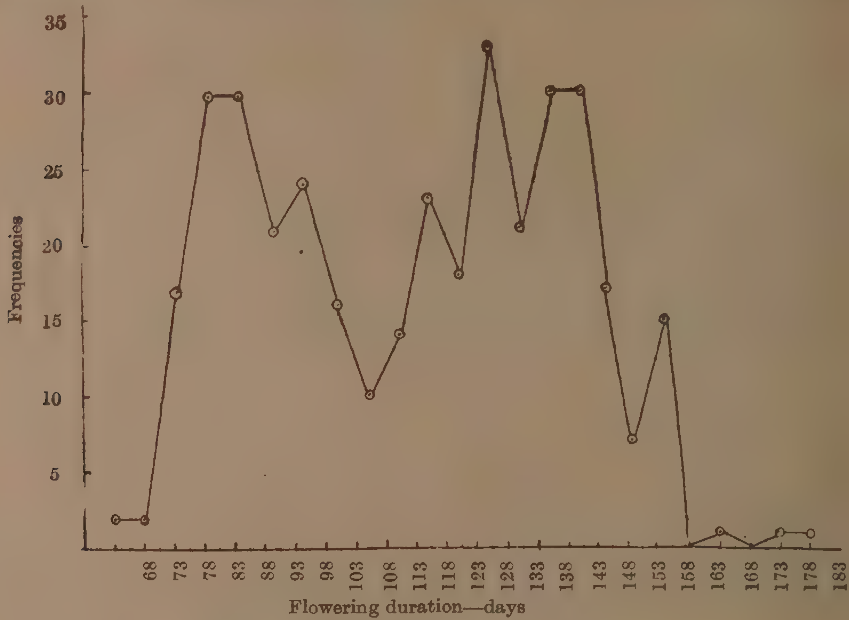

FIG. 6. Cross No. 1520—F_2 generation

Out of the 68 cultures of the cross No. 1520 studied in F_3 (Appendix) all the 25 early cultures bred true, while most of the intermediates segregated with a break as noticed in F_2. One intermediate culture (No. 103) was observed to be pure. Of the 11 late cultures five were found to be definitely pure, while slight fluctuations were noticed in four. Two of the lates, however, behaved like intermediates.

SUMMARY

Several crosses were made between some of the summer, autumn and. winter rices. The object of this study was to investigate the mode of inheritance of earliness of different classes of Surma Valley rice. The earliest type of paddy in our recommended list belongs to summer rice and is named D 138-6 The quest for a very early type with moderate yield had been going on, but unfortunately the earliest types hitherto tested possessed some defects which rendered it unwise to recommend them to the paddy growers. Hybridization was, therefore, resorted to for the production of high-yielding early types of paddy.

In a cross between a summer and an autumn rice there was a difference of about 41 days in flowering between the two parents. The F_1 plants were more or less intermediate, inclined much towards the early parent. The actual segregation of the F_2 progenies showed about a normal curve extending on one side and probably representing a multiple factor inheritance. The transgressive segregation was rather one-sided, i.e. the early plants were as early as the early parent, while some of the late plants were much later than the late parent. Two more crosses between the summer and autumn rices showed practically the same result.

In a cross between an autumn and a winter rice, the F_1 was definitely intermediate and the F_2 had a wide range of variations with transgressive segregation on both sides. Graphically, the F_2 population segregated with a bi-modal curve showing clearly a ratio of 3 late : 1 early.

In two other crosses between the summer and the winter rices, the F_1 was intermediate and in F_2 the transgression was again one sided, i.e. towards the lateness only.

Study of F_3 generation further showed the improbability of getting types earlier than the earliest parent. It is, therefore, not possible to obtain types earlier than the earliest parents as revealed from this study.

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APPENDIX

Cross No. 1520—frequency distribution of flowering duration in F_3 cultures

Culture No.	F_2 duration	F_3 mean	64	69	74	79	84	89	94	99	104	109	114	119	124	129	134	139	144	149	154	159	164	169	174	179	184	189	194	199	204	209	214	Total
Parents D 138—6	72	69	4	31	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	39
Parents S 22	165	164	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	33	1	...	...	...	...	...	...	...	...	...	38
188	66	70	10	38	29	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	79
6	68	65	59	17	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	77
42	73	72	6	27	20	8	2	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	65
34	77	80	1	5	24	15	22	8	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	79
5	79	69	8	29	8	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	47
97	80	74	4	25	22	14	4	2	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	73
100	80	74	...	20	42	10	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	76
29	81	77	...	3	39	32	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80
39	82	80	...	2	31	18	13	5	3	2	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	76
38	83	79	...	...	32	25	14	6	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80
31	84	83	...	...	3	24	31	11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	69
35	84	84	...	...	2	13	9	4	5	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	35
24	85	86	...	...	...	8	43	16	7	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	76
68	85	78	...	1	31	29	14	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	77
73	86	90	...	...	2	12	17	15	10	6	3	3	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	70
85	86	79	...	3	23	25	23	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	79
12	87	77	1	11	29	21	12	2	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80
75	88	81	...	10	19	15	15	14	3	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80
93	88	81	...	3	10	20	24	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	63
89	89	90	...	...	...	1	22	28	16	12	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80
27	90	101	...	...	...	1	3	9	14	19	5	5	11	5	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	73

94	91	88	...	1	3	11	19	26	9	8	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	79
3	93	93	...	...	...	1	15	26	9	14	5	4	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	76
37	93	102	...	...	...	...	1	11	19	19	5	3	14	8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80
1	96	82	...	...	4	35	32	4	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	78
8	97	147	...	1	3	...	...	...	...	...	1	...	...	...	1	6	8	1	2	10	22	12	8	2	...	1	2	...	...	...	...	...	...	80
17	99	96	1	8	9	14	4	1	4	9	4	5	4	6	3	1	3	...	...	2	...	...	1	...	...	...	...	...	...	...	...	...	...	79
82	99	104	...	2	10	13	8	1	...	1	2	2	7	5	9	6	6	3	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	77
78	104	126	...	...	...	...	...	...	1	1	...	4	2	12	14	14	9	5	...	2	...	1	...	...	...	...	...	...	...	...	...	...	...	65
72	105	115	...	2	7	16	7	1	...	1	...	2	1	7	2	...	10	2	7	1	4	...	2	1	2	3	1	...	...	...	...	...	...	79
80	106	100	3	11	16	[illegible]	3	1	1	1	2	3	6	6	4	3	2	4	2	2	1	2	1	...	...	...	...	...	...	...	...	...	...	79
77	108	106	...	1	9	7	8	5	1	...	...	1	...	4	3	...	4	3	2	1	...	1	...	1	1	2	...	...	...	...	...	...	...	54
86	108	113	...	...	17	7	1	1	1	4	1	2	4	7	3	2	5	3	1	4	5	1	3	3	...	...	...	...	...	...	...	...	...	75
90	110	112	...	...	...	5	10	8	1	6	1	2	2	11	2	1	15	9	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	75
10	111	109	...	...	1	[illegible]	3	11		3	6	4	12	18	10	2	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	79
47	111	115	...	...	3	3	5	2	1	1	...	2	7	22	8	5	4	6	1	...	...	...	...	...	..	...	...	...	...	...	...	...	...	70
98	116	124	...	...	...	...	1	3	...	4	1	...	4	12	11	5	19	6	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	68
14	120	127	...	...	1	...	9	2	2	...	...	...	...	...	1	...	1	2	4	3	3	1	...	...	...	...	3	2	...	...	...	...	...	34
32	120	121	...	...	...	1	4	4	1	1	...	...	...	5	16	4	3	4	8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	51
36	120	113	...	1	5	8	8	2	1	3	...	...	...	4	19	1	12	11	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	76
101	121	123	...	...	6	2	...	1	...	1	...	...	...	...	4	17	22	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	60
61	122	117	...	...	...	2	8	6	3	3	1	...	2	3	24	14	5	5	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	79
66	127	119	...	...	...	3	2	5	2	...	1	...	...	...	...	4	15	4	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	38
79	127	121	...	...	2	8	8	3	...	3	2	2	2	3	4	6	7	6	4	4	3	2	2	2	1	1	...	...	...	...	...	...	...	75
74	129	133	...	...	2	1	...	...	...	...	...	...	3	8	3	3	8	20	14	3	1	...	...	...	...	...	...	...	...	...	...	...	...	66
102	129	130	...	...	...	...	...	...	...	...	...	...	...	...	30	22	9	7	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	73
78	130	119	...	...	5	4	6	3	1	1	1	...	...	3	3	2	6	9	3	4	5	2	...	...	...	...	...	...	...	...	...	...	...	58
69	133	132	...	...	...	...	2	...	...	1	1	2	4	...	...	1	4	13	6	2	1	...	...	...	...	1	...	...	...	...	...	...	...	38
88	133	127	...	...	...	4	4	8	1	...	...	...	...	...	...	1	24	25	13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80
71	138	128	...	...	1	1	4	6	5	1	...	...	...	3	3	2	4	12	10	10	4	3	1	...	...	...	...	...	...	...	...	...	...	70
30	139	134	...	...	...	1	2	2	3	2	...	...	3	...	3	...	3	11	8	7	6	2	4	...	...	...	...	...	...	...	...	...	...	57

APPENDIX—*contd.*

Culture No.	F_3 duration	F_3 mean	64	69	74	79	84	89	94	99	104	109	114	119	124	129	134	139	144	149	154	159	164	169	174	179	184	189	194	199	204	209	214	Total
76	140	135	...	...	...	1	5	10	1	1	...	1	...	...	...	...	6	14	10	4	10	3	5	1	2	1	...	1	1	...	...	...	...	77
84	140	124	...	...	9	10	3	...	1	...	...	1	1	...	8	7	11	4	1	5	5	...	4	2	...	...	3	2	...	...	...	...	...	77
57	143	127	...	...	...	2	5	6	3	6	5	2	...	3	...	1	1	6	5	15	6	3	4	2	1	1	...	1	...	...	...	...	...	78
81	143	140	...	1	1	1	1	...	1	...	...	...	...	3	8	2	2	10	18	13	9	4	2	...	2	...	...	...	...	...	...	...	...	78
87	144	126	...	...	...	1	...	4	4	12	3	1	...	...	3	6	5	11	11	7	6	1	...	...	...	...	...	...	...	...	...	...	...	75
83	146	139	...	1	...	3	1	1	3	...	...	2	...	...	6	5	1	7	14	14	10	3	5	...	...	1	...	2	...	...	...	...	...	79
25	150	167	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	1	...	...	18	12	15	7	8	3	2	...	1	...	...	...	69
40	150	137	...	...	...	...	...	...	2	4	10	3	2	...	...	...	1	3	7	22	18	3	...	...	...	...	...	...	...	...	...	...	...	75
2	156	139	...	...	...	...	...	...	...	2	10	5	...	...	...	...	...	...	...	24	7	9	1	...	...	...	...	...	...	...	...	...	..	58
16	156	148	...	...	...	...	...	...	2	2	1	...	...	...	1	4	7	2	5	13	15	15	3	2	2	2	1	...	...	...	...	...	...	77
103	156	156	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	8	2	25	25	4	4	2	2	...	...	...	...	...	...	...	78
83	157	147	...	...	...	2	1	1	...	...	...	...	...	...	...	2	4	4	4	5	21	15	2	1	...	1	1	1	...	...	...	...	...	65
92	160	150	...	...	...	...	1	1	...	1	...	...	1	...	...	...	1	14	7	7	16	15	3	3	2	2	1	...	...	...	...	...	...	75
96	160	164	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	14	21	20	5	1	2	7	4	...	...	...	...	...	76
185	166	167	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16	36	11	3	5	5	...	2	...	...	...	...	78
158	179	182	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8	8	19	24	14	6	...	...	...	...	79
340	181	191	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	11	31	23	[illegible]	3	...	2	76

ELEVEN YEARS' RESULTS OF CONTINUOUS MANURING OF PADDY AT MANDALAY

BY

U TIN

Statistician, Agricultural College, Mandalay

(Received for publication on 10 May 1940)

(With one text-figure)

I. Introduction

THE present study is an examination of eleven years' data from the paddy permanent manurial experiment conducted at the Mandalay Agricultural College Farm since 1927. The experiment consists of 74 plots, each of $0 \cdot 1$ acre, arranged in two rows of 37 plots. The plots were originally laid down in 1924-25 but as no record had been kept of previous treatments two crops without manures were taken in the years 1924-25 and 1925-26 in order to reduce plot differences.

The object of the experiment is to study the influence of various manures on the soil of the Mandalay Farm and in particular the manner in which the soil fertility is affected by repeated applications of chemical and organic fertilizers.

II. Manurial treatments

The manurial dressings were as follows :

(*a*) Lime, 5 cwt CaO per acre, once in four years ; second application in 1930-31 and third application in 1934-35

(*b*) Sodium nitrate, 40 lb. N_2 per acre

(*c*) Ammonium sulphate, 40 lb. N_2 per acre

(*d*) Superphosphate, 40 lb. P_2O_5 per acre

(*e*) Bone-meal, 40 lb. P_2O_5 per acre

(*f*) Potassium sulphate, 40 lb. K_2O per acre

(*g*) Ammonium sulphate, 40 lb. N_2 per acre *plus* superphosphate, 40 lb. P_2O_5 per acre

(*h*) Ammonium sulphate, 40 lb. N_2 per acre *plus* superphosphate, 40 lb. P_2O_5 per acre *plus* potassium sulphate, 40 lb. K_2O per acre

(*i*) Farmyard manure, 40 lb. N_2 per acre

The manures were applied shortly before transplanting, and the variety of paddy grown is Ngasein C 2104. The plots are irrigated, the average rainfall being only about 33 in. The soil is a heavy black clay of the carbonate solontschak type having a *p*H of about $8 \cdot 05$.

III. Layout and method of analysis

The experiment is laid out in two series of two blocks each with 37 plots in each series. Each plot is 165 ft. $\times$ 26 ft. 5 in. or 1/10th acre approximately. Of the 74 plots, 38 are used as controls (without manures) and the nine manurial treatments are replicated four times. The actual layout is shown in the diagram, and it will be seen that treated and untreated plots alternate.

Size of plot = 165 ft. × 26 ft. 5 in. = 1/10 acre

Bund between plots = 4 ft.

N

		IRRIGATION CHANNEL		
	Planted not weighed		Planted not weighed	
'C' Block	38. Control		1. Control	'A' Block
'C' Block	39. Lime		2. Lime	'A' Block
'C' Block	40. Control		3. Control	'A' Block
'C' Block	41. Sodium nitrate		4. Sodium nitrate	'A' Block
'C' Block	42. Control		5. Control	'A' Block
'C' Block	43. Ammonium sulphate		6. Ammonium sulphate	'A' Block
'C' Block	44. Control		7. Control	'A' Block
'C' Block	45. Superphosphate		8. Superphosphate	'A' Block
'C' Block	46. Control		9. Control	'A' Block
'C' Block	47. Bone-meal		10. Bone-meal	'A' Block
'C' Block	48. Control		11. Control	'A' Block
'C' Block	49. Potassium sulphate		12. Potassium sulphate	'A' Block
'C' Block	50. Control		13. Control	'A' Block
'C' Block	51. $(NH_4)_2SO_4$ + super		14. $(NH_4)_2SO_4$+super	'A' Block
'C' Block	52. Control		15. Control	'A' Block
'C' Block	53. $(NH_4)_2SO_4$ + super + K_2SO_4		16. $(NH_4)_2SO_4$ + super + K_2SO_4	'A' Block
'C' Block	54. Control		17. Control	'A' Block
'C' Block	55. Farmyard manure		18. Farmyard manure	'A' Block
'D' Block	56. Control		19. Control	'B' Block
'D' Block	57. Lime		20. Lime	'B' Block
'D' Block	58. Control		21. Control	'B' Block
'D' Block	59. Sodium nitrate		22. Sodium nitrate	'B' Block
'D' Block	60. Control		23. Control	'B' Block
'D' Block	61. Ammonium sulphate		24. Ammonium sulphate	'B' Block
'D' Block	62. Control		25. Control	'B' Block
'D' Block	63. Superphosphate		26. Superphosphate	'B' Block
'D' Block	64. Control		27. Control	'B' Block
'D' Block	65. Bone-meal		28. Bone-meal	'B' Block
'D' Block	66. Control		29. Control	'B' Block
'D' Block	67. Potassium sulphate		30. Potassium sulphate	'B' Block
'D' Block	68. Control		31. Control	'B' Block
'D' Block	69. $(NH_4)_2SO_4$ + super		32. $(NH_4)_2SO_4$ + super	'B' Block
'D' Block	70. Control		33. Control	'B' Block
'D' Block	71. $(NH_4)_2SO_4$ + super + K_2SO_4		34. $(NH_4)_2SO_4$ + super + K_2SO_4	'B' Block
'D' Block	72. Control		35. Control	'B' Block
'D' Block	73. Farmyard manure		36. Farmyard manure	'B' Block
'D' Block	74. Control		37. Control	'B' Block
	Planted not weighed		Planted not weighed	

The layout is unsatisfactory because of want of randomization and of the multiplicity of untreated plots. These may lead to a biased estimate of error. Fisher's [1934] method of analysis has, however, been used on the assumption that the condition of randomness is approximately satisfied although the treatments are not properly randomized.

IV. Relative efficiency of various manurial treatments

The yields of all the plots of the four replications for 11 years, excepting those of plot Nos. 37 and 74 which are the end odd plots in each series, are analysed together. The variance has been split into: (1) influence of blocks, (2) effect of various manurial dressings, (3) effect of annual fluctuations, (4) differential response of the treatments with respect to season, and (5) steady deterioration of the soil. From the yields of only 72 plots for each year there were 791 degrees of freedom available. The details of the analysis are given in Table I.

TABLE I

Analysis of variance of yields in kg.

	Degrees of Freedom	Sum of squares	Mean square	Observed value of F
Blocks	3	9,935·3758	3,311·7919	49·6152
Treatments	9	107,740·8738	11,971·2082	179·3453
Regression	(1)	(69·0929)	69·0929	1·0352
Deviations from regression .	(9)	(62,846·3213)	6,982·9246	104·6139
Years	10	62,915·4142	6,291·5414	94·2560
Interaction between treatments and years	90	10,127·4193	112·5268	1·6858
Residual error . . .	679	45,322·8978	66·7495	
Total . . .	791	236,041·9809		

The following conclusions can be drawn:

(1) The treatment differences are significant (P less than 0·01).

(2) The seasonal differences are significant (P less than 0·01).

(3) Further analysis indicates that the deterioration as shown by the linear function is insignificant (P greater than 0·05).

(4) Block differences are highly significant (P less than 0·01).

(5) The relative efficiencies of the manurial treatments show significant variation from year to year, i.e. there is definite differential response of the treatments to years (P less than 0·01).

Soil variation

As the experiment was laid out in four replications in two adjacent parallel rows, partition of the block variance into three portions is possible. It is given in Table II.

TABLE II

Analysis of block variance (yields in kg.)

Due to	Degrees of freedom	Sum of squares	Mean square
Series	1	4,683·7791	4,683·7791
Columns	1	5,230·2584	5,230·2584
Residual block variance . . .	1	21·3383	21·3383
Total for blocks	(3)	(9,935·3758)	3,311·7917
Error	679	45,322·8978	66·7495

The above analysis shows that the high value of block variance is due to the presence of highly significant differences between one series and the other and between one column and the other.

TABLE III

Mean yields of blocks in lb.

	Block A	Block B	Block C	Block D	Mean	S. E. diff.	C. D. at 5 per cent point
Mean yields in lb.	1,576·26	1,455·72	1,676·23	1,570·18	1,569·60	18·113	35·592

The mean difference in yield of the two series is $4\cdot8637\pm0\cdot5807$ and the mean difference between the two columns is $5\cdot1395\pm0\cdot5807$. From this it follows that the fertility slope runs from east to west, and from north to south.

V. ANNUAL FLUCTUATIONS

The analysis of variance definitely indicates that the mean yields vary considerably from year to year. The annual mean yields are given in Table IV and graphically in Fig. 1.

TABLE IV

Mean yields of Ngasein in lb. per acre

Year	Mean yield	General mean	S. E. diff.	C. D. at $P=0\cdot05$
1927	1,523·29			
1928	1,633·76			
1929	1,500·44			
1930	1,242·32			
1931	1,586·76			
1932	1,810·71	1,569·60	30·0203	59·0000
1933	1,687·76			
1934	1,858·88			
1935	1,685·95			
1936	1,201·13			
1937	1,534·65			

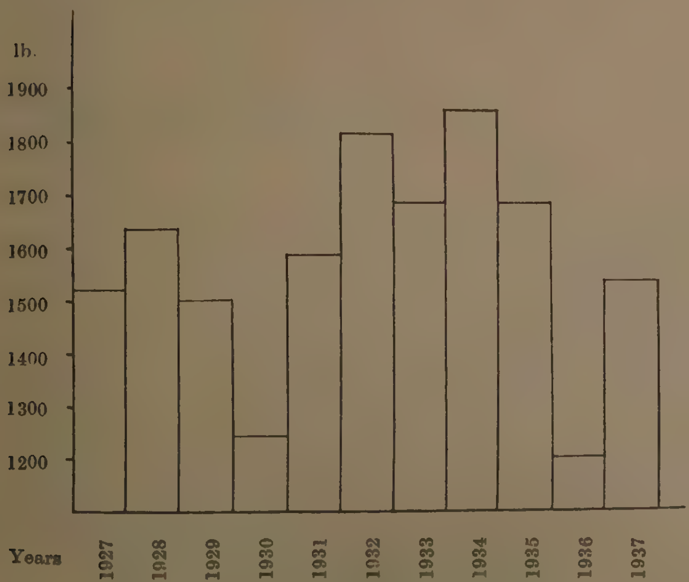

FIG. 1. Mean yields of Ngasein in lb. per acre

Thus the yield varied from 1,858·88 lb. per acre in 1934 to 1,201·13 lb. in 1936. These differences must be attributed to various factors, such as rainfall (especially rainfall during the flowering period), humidity, temperature, pests, etc. together with other variations such as those caused by changes in the method of cultivation, steady changes and other types of fluctuation in the soil due to continuous cropping.

Variance due to steady deterioration, which forms part of the annual fluctuation, is insignificant, while the variance due to deviation from the linear regression is significant. This shows the presence of various types of non-linear variation other than those which cause steady linear deterioration.

The mean yields of the treatments are given in Table V.

TABLE V

Mean yields in lb. per acre of 10 treatments

Order of merit	Treatments	Mean* yields in lb. per acre	S. E. diff. and C. D. ($P=0·05$) for comparing one treatment against another	S. E. diff. and C. D. ($P=0·05$) for comparing treated against control
9	No manure (Control)	1,402·08		
7	Lime	1,449·29		
6	Sodium nitrate	1,473·64		
5	Ammonium sulphate	1,779·97		
4	Superphosphate	1,936·09	S.E. diff. = 38·411 C. D. = 75·478	S. E. diff. = 28·620 C. D. = 56·238
8	Bone-meal	1,446·43		
10	Potassium sulphate	1,401·06		
1	Ammonium sulphate + superphosphate	2,076·21		
2	Ammonium sulphate + superphosphate + potassium sulphate	2,054·49		
3	Farmyard manure	2,016·91		

* The mean yield for the control is calculated from the total of 396 plot yields and for other treatments from totals of 44 plot yields each.

All the manures except lime, bone-meal and potassium sulphate show significant increases over the untreated plots. Of the effective manures sodium nitrate is just significantly better than no manure, while ammonium sulphate alone is very much better than sodium nitrate but inferior to all phosphatic manures and to farmyard manure. Superphosphate alone, though inferior in yield to the two manurial combinations, has given a greater increase in yield from year to year as shown by the analysis given later.

The three manures applied on a nitrogen-content basis differ from one another significantly. From the mean yields it seems that nitrogen in organic form is the best while nitrogen as ammonia comes second.

VI. Effect of the unconsumed residue of the fertilizers on the yield of the succeeding crop

Proceeding now to a consideration of the variation in yield of treated plots from year to year, of the several causes of annual fluctuation in yield the two most important considered here are pure seasonal fluctuation and the cumulative effect of the manures applied in previous seasons.

Fisher [1921] and Kalamkar and Singh [1935] recognize three types of variations : (1) Annual fluctuations, (2) Fluctuation due to soil deterioration, (3) Slow changes other than a steady deterioration. In order to assess the effect of soil deterioration and of slow changes, it is necessary to have data for a period of 30 to 40 years for the same plot. Such data are not available in Burma at present and will not be available for many years. Meanwhile it is desirable to examine whether any large trends follow or are likely to follow the continued use of certain artificials.

The present data relate to an experiment which has lasted only for eleven years, which is too short a time for an analysis of all three types of variation. Therefore, only the variation caused by the cumulative effects of the manurial treatments is considered, this being the point on which information is urgently desired. If it is assumed that season affects the yield of treated and untreated plots alike, then the seasonal effect on the yields of the manured plots can be treated as a partial regression on the yields of the untreated. On this assumption the following multiple regression has been fitted to the yield data :—

$$y-\bar{y}=b_1\ (x_1-\bar{x}_1)+b_2\ (x_2-\bar{x}_2)$$

where y is the yield of the manured plot, x_1 the progressive number of doses of manure and x_2 the yield of the corresponding control.

The analysis is given in Table VI. Lime is omitted as it was only applied once in four years.

In all cases except superphosphate and farmyard manure the standard errors of the regression coefficients of the cumulative doses on the yield are proportionately so high that significance is not attained. Superphosphate in combination with ammonium sulphate, with or without potassium sulphate, fails to give a significant regression of cumulative dose effect. The marked negative trend of ammonium sulphate alone, though not significant, may be surmised to have reduced the positive superphosphate trend so as to cause it to fail in significance.

It therefore seems likely that the continued use of ammonium sulphate alone may lead to a decline in yield and that the continued use of superphosphate will tend to build up fertility. So far as these studies go, on a very limited scale, there would therefore appear to be no danger in repeated applications of the newer types of ammonio-phosphatic fertilizers such as are generally recommended for paddy in Burma, but the question remains as to whether the inclusion of nitrogen is worth while and whether in the long run phosphate alone

may not raise the fertility level more and ultimately prove equally or more profitable.

TABLE VI

Analysis of variance (11 years)

(Calculated on yield in kg.)

Manure	Due to		Degrees of freedom	Mean square	Regression coefficients	
					Cumulative dose effect b_1	On yields of control b_2
Sodium nitrate	Blocks		3	452·3589		
	Regression functions	b_1	1	107·4980		
		b_2	1	4,287·2106	−1·1439±1·482	+0·9742±0·1166
	Deviations from regression		8	58·3698		
	Annual fluctuation		(10)	486·1667	R=0·9508	
	Error		30	56·9108		
Ammonium sulphate	Blocks		3	438·9180		
	Regression functions	b_1	1	68·4444		
		b_2	1	3,949·6400	−2·6302±1·558	+0·8907±0·1149
	Deviations from regression		8	65·0270		
	Annual fluctuation		(10)	453·8301	R=0·9410	
	Error		30	37·9457		
Superphosphate	Blocks		3	128·3240		
	Regression functions	b_1	1	3,838·4134		
		b_2	1	3,100·9268	+12·3184±1·8858	+0·9685±0·1633
	Deviations from regression		8	97·0168		
	Annual fluctuation		(10)	771·5475	R=0·9455	
	Error		30	34·8765		
Bone-meal	Blocks		3	39·7760		
	Regression functions	b_1	1	177·6997		
		b_2	1	3,332·4826	+3·1185±2·445	+0·8612±0·1887
	Deviations from regression		8	162·9242		
	Annual fluctuation		(10)	483·3576	R=0·8522	
	Error		30	59·3836		
Potassium sulphate	Blocks		3	257·0431		
	Regression functions	b_1	1	123·5990		
		b_2	1	2,140·0307	−2·0989±1·264	+0·7516±0·1080
	Deviations from regression		8	43·9903		
	Annual fluctuation		(10)	261·5553	R=0·9303	
	Error		30	43·9482		

TABLE VI—*contd.*

Manure	Due to		Degrees of freedom	Mean square	Regression coefficients	
					Cumulative dose effect b_1	On yields of control b_2
Ammonium sulphate +superphosphate	Blocks		3	119·6447		
	Regression functions	b_1	1	313·3749		
		b_2	1	1,314·1318	+3·7390±4·119	+0·5765±0·3500
	Deviations from regression		8	462·1837		
	Annual fluctuation		(10)	532·4976	R=0·5528	
	Error		30	43·1587	(Not significant)	
Ammonium sulphate +superphosphate +potassium sulphate	Blocks		3	232·7198		
	Regression functions	b_1	1	332·0372		
		b_2	1	1,829·1745	+4·0357±3·580	+0·6547±0·2806
	Deviations from regression		8	347·0523		
	Annual fluctuation		(10)	493·7630	R=0·6616	
	Error		30	45·4607	(Passes the 5 per cent point)	
Farmyard manure	Blocks		3	209·3569		
	Regression functions	b_1	1	3,466·7077		
		b_2	1	2,637·5091	+12·0847±4·030	+0·9437±0·3533
	Deviations from regression		8	436·1186		
	Annual fluctuation		(10)	959·3642	R=0·7977	
	Error		30	87·6373		

Of the two sets of regression coefficients the more interesting one—the cumulative dose effect on the yield—shows that in the cases of superphosphate and farmyard manure, if the yields of the controls were constant, an addition of one dose would cause an increase of about 30 kg. or 66 lb. of paddy per acre per annum.

The multiple correlation coefficients are significant in all cases except for ammonium sulphate *plus* superphosphate. The significance in most cases is due to the close relation in behaviour towards the weather effects by the treated and untreated.

Analysis also shows clearly (Table VI) that the two factors together account for a significant fraction of the total variance due to annual causes. For superphosphate the total sum of squares due to the regression functions is 6,939·3402, which is proportionately contributed by the two influencing factors, their sums of squares being 3,838·4134 and 3,100·9268. Farmyard manure behaves in a similar way, the total sum of squares, 6,104·2168, being made up of 3,466·7077 and 2,637·5091, which are respectively the sum of squares of the regression function of the cumulative dose and of the yield of the corresponding controls. In both cases it is interesting to note that the cumulative dose effect takes the larger share of the contribution towards the total sum of squares.

In all other cases the contribution towards the total sum of squares by the cumulative dose effect is disproportionately low in comparison with the share contributed by the regression function of the yield of the corresponding control. Especially is this so in the case of the two nitrogenous manures, ammonium sulphate and sodium nitrate, where the sum of squares due to cumulative dose effects are only 68·444 in 4,018·0844 and 107·4980 in 4,394·9086 respectively.

VII. Summary

1. The yields of paddy (Ngasein C2104) of the permanent manurial experiment at Mandalay from 1927 to 1937 have been analysed.

2. The effects of cumulative doses of various manures in relation to the corresponding control have been studied.

3. Multiple regressions have been fitted to the annual mean yields.

4. It has been observed that the relative efficiency of manurial treatments shows significant variation from year to year.

5. The presence of non-linear variations other than those which cause steady linear deterioration is apparent.

6. Of the three nitrogenous manures, organic manure is the best with respect to the yield of paddy grain, while ammonium sulphate is much superior to sodium nitrate.

7. Bone-meal shows no significant increase. This was to be expected in a soil of about *p*H 8·0.

8. It has been observed also that of all the artificials only superphosphate applied alone at the rate of 40 lb. P_2O_5 per acre has shown a significant upward trend.

9. Farmyard manure shows a similar effect to superphosphate, though not so highly significant.

10. Sodium nitrate and ammonium sulphate show negative trends. The former's trend is quite insignificant but that of the latter only just fails to reach significance.

11. The combined manures, ammonium sulphate *plus* superphosphate and ammonium sulphate *plus* superphosphate *plus* potash show positive trends, but they are quite insignificant. It is suggested that the negative effect of ammonium sulphate has largely counteracted the significantly positive effect of superphosphate.

This work has been carried out under the supervision of Mr D. Rhind, I.A.S., Economic Botanist, Burma, to whom the author is greatly indebted for his suggestions and assistance in writing this paper, and also to the Professor of Agriculture for making the data available.

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FURTHER OBSERVATIONS ON STERILITY IN COTTON

BY

K. RAMIAH

AND

P. D. GADKARI

Institute of Plant Industry, Indore, Central India

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Introduction

HUTCHINSON and Gadkari [1935] described two sterile mutants in 'Million Dollar' (*G. arboreum* var. *neglectum* forma *burmanica* H. & G.), a strain of Asiatic cottons. It was shown there that the sterility of one of the plants—rogue B—was due to a single recessive gene to which Hutchinson and Silow [1939] have given the symbol **stp**. Fertility was fully dominant. It was further pointed out that the sterility though not quite complete was equal on both male and female sides. The percentage of shrivelled pollen grains varied among different sterile plants but it was always more than 70, whereas fertile plants had never more than 10 per cent bad pollen.

Cytology

Young anthers of both sterile and fertile plants were fixed in Carnoy's fluid and examined in acetocarmine. The fertile plants showed the normal tetrad formation, whereas in sterile plants usually six to eight unequal cells are formed from the division of the pollen-mother cell, rarely four as in a normal plant. This suggested some abnormality in the meiosis under genic control.

Fig. 1. Diakinesis stage of the pollen-mether cell of a sterile plant ($\times$ 3033)

A number of spore mother cells from different sterile plants were examined at diakinesis. All of them were characterized by a number of univalents, a few bivalents and some multivalents. One such case is represented in Fig. 1. This compared with the normal pairing, and formation of 13 bivalents in the normal fertile plant (Fig. 3) clearly suggests the absence of normal pairing, asynapsis, as the cause of sterility. In the anaphase stage of the sterile plant (a case represented in Fig. 2) one can see considerable fragmentation of the chromosomes and bridge formations.

FIG. 2. Anaphase stage of a sterile plant ($\times$ 3033)

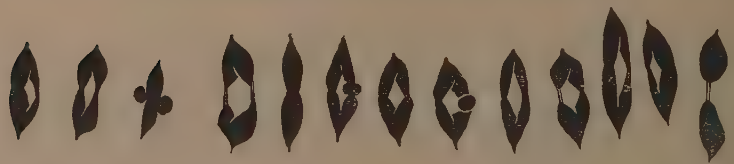

FIG. 3. Normal metaphase pairing—from a normal fertile plant—showing regular pairing and 13 bivalents ($\times$ 3033)

Similar asynaptic mutants have been reported by different workers in other plants, viz. *Zea* [Beadle, 1930], *Nicotiana* [Clausen, 1931], *Avena* [Huskins and Hearne, 1933], *Datura* [Bergner *et al.*, 1934], *Crepis* [Richardson, 1935], *Oryza* [Ramanujam and Parthasarthy, 1936], and *Pisum* [Koller, 1938]. In most of these cases definite reasons for the failure of the metaphase pairing have been suggested. The exact behaviour of the chromosomes leading to asynapsis in the present case is under investigation and is outside the scope of this note.

LINKAGE RELATIONS

Crosses detailed below were effected to study the linkage relations of this gene with other known ones in cotton. Owing to the failure of seed production in the homozygous steriles, both on selfing and on crossing, the heterozygous

fertiles were utilized for the purpose. Due to complete dominance of fertility, however, it was impossible to distinguish between homozygous and heterozygous fertiles except by progeny tests. Crosses were therefore made with several fertile selections from a segregating progeny. All the crosses that happened to be made with the homozygous fertiles were discarded, attention being confined to series where the heterozygous fertile was the parent.

The heterozygous fertiles were homozygous for yellow corolla (**Ya**) and anthocyanin gene $\mathbf{R}_2^{As}$. These were crossed to N6, a type with white corolla (**yy**) and ghost spot $\mathbf{R}_2^{Os}$. The results are discussed below.

Heterozygous fertile ×N6

N6 was successfully hybridized with two heterozygous fertile plants, viz 384 and 494. All the F_1 plants were perfectly fertile and had yellow corolla and petal spot. The F_2 showed, as expected, two types of families with regard to sterility distribution. Some bred true for fertility while others segregated into fertiles and steriles. The distribution of the families in F_2 was as follows :–

	Families giving all fertiles	Families segregating into fertiles and steriles	Total
N6×384	6	4	10
N6×494	2	2	4
Total (observed)	8	6	14
Total (expected)	7	7	14

$\chi^2=0\cdot28$, $n=1$, $P=0\cdot70\text{-}0\cdot50$: Good fit

The total fertiles and steriles appearing in F_2 families segregating for sterility were as expected.

	Fertiles	Steriles	Total
N6×384	118	40	158
N6×494	33	15	48
Total (observed)	151	55	206
Total (expected)	153·5	51·5	206

$\chi^2=0\cdot29$, $n=1$, $P=0\cdot70\text{-}0\cdot50$: Good fit

The pooled distribution for corolla colour and anthocyanin genes in families segregating for sterility was as follows :—

	X	x	Total	χ^2	*P*
Anthocyanin	141	39	180	1·06	0·50-0·30
Corolla colour . . .	142	46	188	0·03	0·90-0·80

These figures indicate the usual monogenic behaviour of the genes and as such their segregation in F_2 of double heterozygotes can be utilized for linkage estimation.

(*i*) *Sterility and anthocyanin*

The two-factor distribution for these two characters is given below :—

	Fertiles		Steriles			χ^2		
Family	R_2^{As}	R_2^{os}	R_2^{As}	R_2^{os}	Total	R_2^{As}—R_2^{os}	Stp—stp	(Linkage)
307 . .	9	3	2	3	17	0·96	0·18	2·89
308 . .	39	11	8	3	61	0·14	1·58	0·15
312 . .	28	8	10	3	49	0·17	0·06	0·00
313 . .	5	..	1	..	6	2·00	0·22	0·07
319 . .	24	6	9	2	41	0·66	0·07	0·02
323 . .	5	..	1	..	6	2·00	0·22	0·07
Total .	110	28	31	11	180	1·06	0·27	0·63

Thus the data indicate free assortment. These results were confirmed during the following year when selfed seed from heterozygous fertiles was used to grow an F_3. The double heterozygotes (11 families) gave the following distribution in F_3.

Fertiles		Steriles			χ^2		
R_2^{As}	R_2^{os}	R_2^{As}	R_2^{os}	Total	R_2^{As}—R_2^{os}	Stp—stp	(Linkage)
68	31	25	8	132	1·45	0·00	0·66

Thus there is no linkage between the sterility gene and anthocyanin.

(*ii*) *Sterility and corolla colour*

The crosses and families mentioned above segregated for corolla colour as well. The F_2 segregation was as follows :—

	Fertiles		Steriles			χ^2		
Family	Yellow	White	Yellow	White	Total	Ya—ya	Stp—stp	(Linkage)
307	8	3	2	3	16	1·33	0·33	2·78
308	45	5	7	4	61	3·42	1·58	3·62
312	23	12	12	2	49	0·33	0·33	2·17
313	4	1	..	1	6	0·22	0·22	1·85
319	23	7	11	..	41	1·37	0·07	2·20
323	2	3	..	1	6	5·55	0·22	0·07
Total .	105	31	32	11	179	0·22	0·09	0·14

Eleven double heterozygotes in F_3 gave :

Fertiles		Steriles			χ^2		
Yellow	White	Yellow	White	Total	**Ya—ya**	**Stp—stp**	(Linkage)
50	10	14	6	80	1·07	0·00	1·42

Thus there is no linkage between sterility and corolla colour genes.

(iii) Sterility and leaf shape

Two families in the F_3 of the above cross were found to segregate for leaf shape. Since both the original parents were homozygous for broad leaf (**ll**), the occurrence of these two families can only be ascribed to their being natural crosses. They actually proved to be heterozygous for leaf shape and sterility and exhibited the following two-factor distribution.

Fertiles		Steriles			χ^2		
Narrow	Broad	Narrow	Broad	Total	**L—l**	**Stp—stp**	(Linkage)
21	7	5	3	36	0·51	0·15	0·44

Selfed seed from 16 narrow-leaved fertile plants was used to grow as many families in the following year. Six families bred true to narrow leaf and six segregated into narrows and broads. (Four families with less than five plants in each were dropped out of consideration). The proportion of homozygous and heterozygous narrow families is close to expectation since χ^2 value calculated from the expected figure would be 1·5, and when $n=1$, P would be between 0·80 and 0·20.

The segregating families gave :—

Narrows	Broads	Total
134	46	180

$\chi^2=0\cdot03$, $n=1$, $P=0\cdot90\text{-}0\cdot80$: Good fit

Out of these six families, only four segregated for sterility and their two-character distribution was as follows :—

	Narrows		Broads			χ^2		
Family	Fertiles	Steriles	Fertiles	Steriles	Total	**L—l**	**Stp—stp**	(Linkage)
406	3	2	4	1	10	3·33	0·13	0·40
408	6	5	5	2	18	1·85	1·85	0·22
417	29	12	8	1	50	1·30	0·03	1·07
425	40	6	12	2	60	0·09	4·35	0·03
Total	78	25	29	6	138	0·01	0·47	0·72

Thus sterility and leaf shape assort freely.

Summary

(i) The sterility due to gene **stp** [Hutchinson and Silow, 1939] has been found to be caused by asynapsis.

(ii) This gene assorts freely with the genes controlling corolla colour anthocyanin and leaf shape in Asiatic cottons.

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A BRIEF ACCOUNT OF THE STUDIES ON THE HARMFUL AFTER-EFFECTS OF *CHOLAM* CROP ON COTTON*

BY

V. RAMANATHA AYYAR

Cotton Specialist, Coimbatore

AND

S. SUNDARAM

Agricultural Research Station, Koilpatti

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(With Plates III and IV and four text-figures)

ON the rain-fed black soils of the 'Tinnies' † tract, farmers generally follow a four-course rotation of *cholam*→cotton→*cumbu*→cotton. Of these, *cholam* called locally *irungu* (*Sorghum dochna* var. 7 forma 2 *irungu*) is grown for fodder, while *cumbu* (*Pennisetum typhoideum*) and cotton (a mixture of *G. arboreum* var. *neglectum* forma *indica* H. & G. and *G. herbaceum* var. *frutescens* H. & G.) are respectively their main food and money crops. It is commonly observed there that cotton grown after *cholam* is paler in appearance, shorter in growth and poorer in yield than that coming after *cumbu* (Plate III). The average yield of *kapas* in the former is, according to the data collected at Koilpatti Agricultural Research Station during the past 31 years, 405 lb. as against 471 lb. recorded in the latter. This difference of 16 per cent in yield is of considerable value to the farmers depending on uncertain and deficient rainfall common in arid regions. The harmful effect of *cholam*-growing would, for the sake of convenience, be referred to in the following pages as '*cholam* effect'.

Historical

It may be mentioned that the phenomenon of '*cholam* effect' is not peculiar to the 'Tinnies' tract alone. It has been observed to exist under the conditions obtaining in Coimbatore, Salem and South Arcot districts of the Madras presidency, in parts of Bombay [Fletcher, 1912] and in the United Provinces; and is said by American agronomists [Breazeale, 1924; Conrad, 1927, 1928, 1932, 1937] as a much-dreaded feature of *cholam* growing in their arid and semi-arid tracts. It has been the subject of somewhat extensive studies, particularly in America; and very different hypotheses have been put forward concerning its nature and causes. One school of thought [Harper and Murphy, 1930; Holter and Fields, 1899] declared that the effect was due to the greater depletion of plant foods by the heavier-feeding *cholam*

* Full details will be published in the *Madras Agricultural Journal*.

† This is the name given to portions of Madura Ramnad and Tinnevelly districts of Madras province, where a variety of indigenous cotton called 'Tinnies' is being grown.

crop. It is interesting to note that this opinion is shared by the farmers of the 'Tinnies' tract also. Some workers [Mackinlay, 1931; Sewell, 1923; Ball, 1906; Miller, 1931], however, discountenanced the above view. A second group [Breazeale, 1924; Hawkins, 1925; Sewell, 1923] attributed the *cholam* effect to the production of an easily volatilizable toxic body during the decomposition of *cholam* residues, which killed all the micro-flora. Still another set of workers [Conrad, 1927; Wilson and Wilson, 1928] believed that the higher sugar contents of the *cholam* stubbles encouraged rapid multiplication of micro-organisms and created a nitrogen deficiency in the soil. All of them, despite these differences in their opinion, agreed that the *cholam* effect would be perceptible only on wheat and small grains, especially if they happened to be sown in winter soon after the harvest of *cholam*.

Methods

Experiments were first conducted to verify whether any of the above theories would prove valid under the conditions obtaining in the tract under study. Investigations, with the object of finding out measures that would eliminate or correct the deleterious after-effects of *cholam* growing, were carried out from 1931 to 1937 at Koilpatti Agricultural Experiment Station situated in the heart of the 'Tinnies' tract. They were mostly agronomic in character and conducted on field plots laid out in the form of replicated randomized blocks and sometimes in split-plot fashion. Although the experiments covered a period of six years, conclusions were drawn from the data of seasons when the *cholam* effect was manifest. Such a precaution was necessary since the injurious effects were marked in years of good rainfall and since some of the years in the period of study were unusually droughty.

Summary of results

Soil exhaustion

If the hypothesis of soil exhaustion was applicable, it was apparent from *a priori* grounds that manuring either the cotton crop directly or the previous *cholam* crop should restore the depressed yield of succeeding cotton. Alternatively, if the production of total dry matter in *cholam* was reduced by wider spacing, the cotton yields should improve with the fall in dry matter. The results of experiments tried to elucidate these points negatived such a possibility. In both types of manuring, the depressing effects of *cholam* persisted (Table I).

The results of the above manurial experiments were of interest in another way. They proved that the theory of nitrogen deficiency in *cholam* plots put forward by McGeorge and Breazeale [1936] did not hold good on the black soils of Koilpatti. The cotton yields in the *cholam* plots were lower than those after *cumbu* in spite of their receiving 2 cwt of ammonium sulphate per acre.

Spacing experiments conducted during three seasons led to a similar conclusion. Cotton succeeding *cholam* sown in 36 in. spacing yielded as much as that following *cholam* spaced 6 in. (Table II). It was clear from these that soil exhaustion was not at the bottom of the trouble in question.

TABLE I

Depressing effect of cholam

		Yields of cotton in lb. per acre	
		Manuring cotton directly 1931-32	Manuring the previous crop 1933-34
No manure	After *cholam*	353	244
	After *cumbu*	411	452
Manured (112 lb. super + 224 lb. amm. sulphate)	After *cholam*	573	283
	After *cumbu*	690	517
Critical difference ($P = 0 \cdot 05$)		51	55

TABLE II

Yield of cotton succeeding cholam

	Cotton yields in lb. per acre		
	1934-35	1935-36	1936-37
After *cholam* spaced 6 in. between rows	521	362	232
Do. 18 in. between rows	512	393	223
Do. 36 in. between rows	522	539	221

N.B.—z-test not satisfied.

TOXICITY OF *CHOLAM* RESIDUES

Regarding the validity of this theory, investigations were of three kinds: one relating to the study of the effects of the stubbles only, the second to the decomposition of the roots and the third concerning the root excretions. In the first group of experiments, stubbles were removed from a few plots, while in others definite quantities of stubbles from other fields were added and incorporated. No differences were observed amongst the treatments (Table III).

TABLE III

Yield of seed cotton from plots with and without stubbles

	Yield of seed cotton in lb. per acre			
	1931-32	1932-33	1932-33	1933-34
Stubbles removed	504	556	..	..
Stubbles not removed	512	562	..	..
No stubbles added	..	..	816	470
221 lb. stubbles added	..	..	863	403
442 lb. do.	..	..	..	411
Critical difference ($P = 0 \cdot 05$)	15	55	64	69

In the second group of experiments, the toxicity of the *cholam* roots was sought to be eliminated as recommended by Breazeale [1924], by ploughing the residues early. The data collected pointed that the ploughing had not engendered any more beneficial effect than in the treatment 'not ploughed' (Table IV).

TABLE IV

Yield of seed cotton from ploughed and unploughed plots

	Yield of seed cotton in lb. per acre	
	1932-33	1934-35
Not ploughed . . .	524	450
Ploughed . . .	563	493
Critical difference ($P = 0 \cdot 05$)	67	71

The question of toxic excretion of the roots was considerably more difficult to tackle by means of simple agronomic experiments on account of the underground location of the roots. Indirect evidence was therefore sought by studying the effects of the soil leachates on cotton plants raised in pots. Soil cores one foot in diameter and one foot in depth were removed from the first and second foot layers of the plots cropped with *cholam* and *cumbu*, as well as from fallow plots. Definite quantities of water were allowed to percolate through each core and the leachates were used to irrigate cotton plants raised in sand cultures. The plants showed no differences in growth. It was inferred that *cholam* soils did not contain leachable toxic products in such quantities as to be harmful to plant growth.

MOISTURE STUDIES

Apart from these, the low rainfall, the aridity of the climate obtaining in the 'Tinnies' tract and the close spacing * adopted in the growing of *cholam* suggested that insufficiency in soil moisture might have acted as a limiting factor in the 'after-*cholam*' plots. Such a possibility gained some strength from the reports made by Conrad [1927, 1937] and Breazeale [1924]. Very extensive studies were carried out for two seasons to settle this doubt. Moisture contents were estimated by drying, in steam oven, soil samples drawn periodically from the harvest of the previous crop till the bolling of the cotton in three sets of replicates of plots cropped with *cholam*, *cumbu* and horse gram, and also from neighbouring fallow plots. Samples of soil

* The seed rate varies from 60 to 100 lb. per acre.

were from one-foot sections taken up to a depth of four feet by means of King's soil sampler. The data when analysed showed (Figs. 1-4) that the moisture contents increased with the depth up to the third foot and that the *cholam* plots, though they happened to be drier till the sowing of cotton, contained more moisture than the 'after-*cumbu*' plots throughout the entire growth period of the cotton crop, in spite of an appreciable lag noticed in the penetration of rain water into the lower layers in the former plots. It was thus made plain that the *cholam* effect could not have been brought about by deficiencies in the soil moisture.

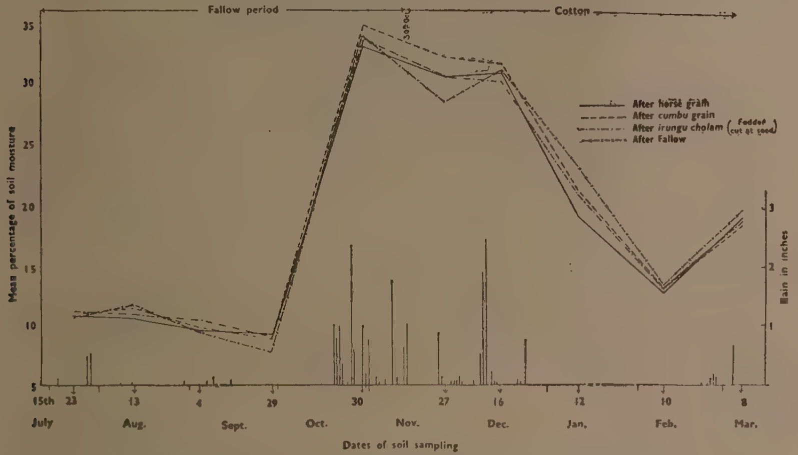

FIG. 1. Soil moisture experiments 1931-32 (first foot)

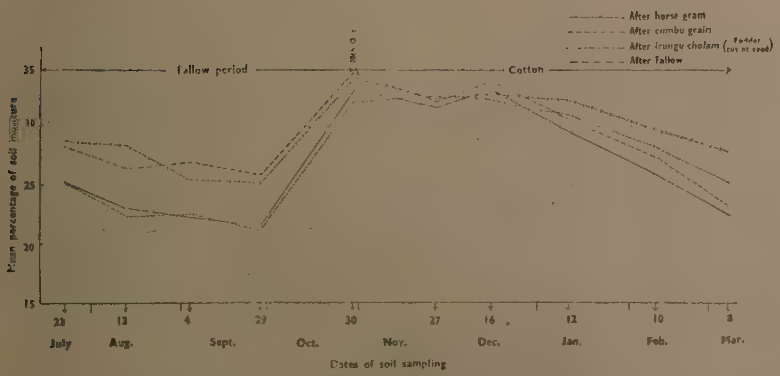

FIG. 2. Soil moisture experiments 1931-32 (second foot)

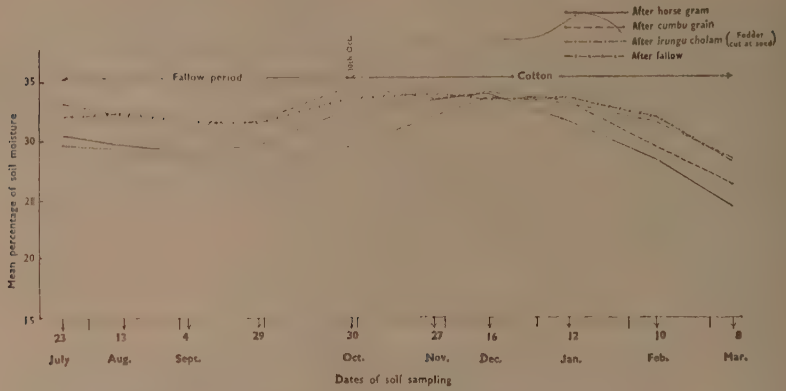

FIG. 3. Soil moisture experiments 1931-32 (third foot)

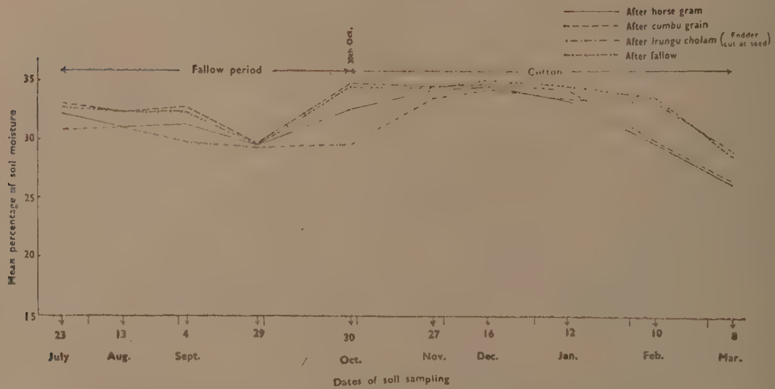

FIG. 4. Soil moisture experiments 1931-32 (fourth foot)

PECULIARITIES OF THE TRACT

The above finding suggest that the phenomenon of '*cholam* effect' under 'Tinnies' conditions is very much different from that met with in America. Besides, there are circumstances which add strength to this conclusion. In the tract under study the effects are felt on a deep-rooted cotton crop unlike on shallow-rooted cereals like wheat and small grains reported in America. In addition, a long summer fallow period having several intermittent showers of rain intervenes between the harvest of *cholam* and the sowing of cotton. The amount of stubbles usually left in 'Tinnies' conditions is also not considerable. It is perhaps only natural that with such distinct differences in the environmental complexes, the two phenomena are not similar in characters and in their relation to external changes.

NEW FEATURES

These investigations were, however, valuable in providing certain important clues about the nature of the *cholam* effect. For instance, it was

found that if *cholam* was cut at shot blade stage, the usual depression in yield associated with the cottons raised on *cholam* plots was not observed ; if, on the other hand, the *cholam* crop was allowed to set seed, the deleterious effects increased with the duration of the seed-setting stage. This observation of the apparent dependence of the *cholam* effect on seed formation was later elaborated to get an insight into the probable causes of the phenomenon. The effects of some new treatments like 'sowing the *cholam* a month late' with the object of reducing the duration, 'cutting *cholam* at milk stage', 'removing *cholam* earheads soon after emergence', 'cutting *cholam* at shot blade stage', 'harvesting *cholam* at shot blade and ratooning', and 'sowing *cholam* thick' to reduce seed setting, and 'retaining the *cholam* crop for two months' more than the normal date of harvesting were studied. The results are set out in Table V.

TABLE V

Yield of seed cotton after cholam *cut at different stages*

	Yield of seed cotton in lb. per acre	
	1934-35	1937-38
After *cholam* cut at seed (control)	417	407
After *cholam* cut at shot blade	626	507
After *cholam* cut at flower	..	556
After *cholam* cut at milk stage	..	457
After *cholam* cut 2 months after seed setting	..	395
After *cholam* cut with earheads removed after emergence	495	452
After *cholam* sown thick and cut at seed	523	..
After *cumbu*	..	661
Critical difference ($P = 0 \cdot 05$)	100	89

It was apparent from Table V that the treatments '*cholam* cut at shot blade' and '*cholam* sown thick' had distinctly better after-effects than the control treatment '*cholam* cut at seed', and that the better of the two, viz. '*cholam* cut at shot blade' was yet behind the cotton yields obtained in 'after-*cumbu*' plots. A point of interest was that the variant *cholam* retained for two months after seed setting gave as much yield of cotton as that from the control '*cholam* cut at seed' plot, indicating thereby that the retention of *cholam* crop beyond the seed-setting stage did not enhance the harmful effect.

The effects of ratooning, which were studied in another series of experiments but with the same object in view, are presented in Table VI.

TABLE VI

Effects of ratooning

	Yield of seed cotton per acre in plots after					
	Cholam cut at seed	*Cholam* cut at shot blade	First *cholam* cut at shot blade: Ratoon cut at flower	First *cholam* cut at shot blade: Ratoon cut at seed setting	Average	Critical difference
After *cholam* sown at normal season	699	749	573	440	615	58
After *colam* sown a month later	669	796	583	501	639	
Average	684	773	581	471		
Critical difference ($P=0\cdot05$)	83					

It was seen from these that the treatment 'ratoon cut at seed setting' reduced the cotton yields more than the 'ratoon cut at flower'. It ruled out the possibility of *cholam* seed-setting as being the cause of the reduced yields, since both types of ratoons did not set seed in spite of retaining them for a long time. The question of duration was also excluded as a possible reason, since the treatment 'ratoon cut at flower' had a lowered yield, in spite of its being of the same duration as the treatment '*cholam* cut at seed'. The operation of ratooning, therefore, appeared to bring about the depression in yield. It is common knowledge that ratooning a crop stimulates its roots to spread further, and it could therefore be taken that penetration of *cholam* roots in the lower layers was responsible for the fall in the yield of seed cotton.

The above clue supplied a good explanation for the entire phenomenon of '*cholam* effect'. The *cholam* crop comes to ear soon after the cessation of the north-east monsoon when the roots are only within the upper layers. When clear weather sets in, and when the soil moisture at the top layers dries up, the roots penetrate into lower depths; and if the *cholam* is ratooned, the roots go further down. As the seeds set, root absorption ceases to a great extent. If a comparison is made with the degree of penetration of roots at different stages of *cholam* growth and the disposition of injurious salts in the soil at different depths (Table VII), a suggestive relationship is found. So long as the roots are in the top layers containing no injurious salts, the deleterious effect is not visible as evidenced by the performances of plots with *cholam* cut at shot blade treatments. When the roots enter the lower regions of the soil profiles containing the injurious salts, the yields of the succeeding cotton are affected to the extent of penetration of the roots. When once the root absorption stops as in the 'beyond-the-seed-setting' stage, further addition to the *cholam* injury is not made.

TABLE VII

Koilpatti black soil profile at different depths

(On percentage basis)

No.	Head of analysis	0—1 ft.	1—2 ft.	2—3½ ft.	3½—4½ ft.	4½—6 ft.	6—7 ft.	7—8 ft.
1	Lime (CaO)	0·0062	0·0016	0·3300	0·3400	0·3300	0·0890	0·0860
2	Magnesia (MgO)	Trace	Trace	0·0610	0·0880	0·0860	0·0320	0·0300
3	Bicarbonate (HCO_3)	0·0310	0·0530	0·0190	0·0210	0·0210	0·0300	0·0260
4	Carbonate (CO_3)	0·0060	...	...	...	...	...	...
5	Sulphate (SO_4)	0·0028	0·0110	0·0760	1·0370	1·1700	0·7000	0·6500
6	Chloride (Cl)	0·0050	0·0060	0·0060	0·0070	0·0080	0·0100	0·0230
7	Total solids	0·0670	0·0950	1·4150	1·9200	2·1400	1·2900	1·2300
	Calculated salts—							
	Calcium bicarbonate	...	...	0·025	0·028	0·028	0·040	0·035
	Calcium carbonate	...	...	...	...	...	...	...
	Calcium sulphate	...	...	0·79	0·81	0·78	0·18	0·18
	Calcium chloride	...	...	...	...	...	...	...
	Magnesium bicarbonate	...	...	...	...	...	...	...
	Magnesium carbonate	...	...	...	...	...	...	...
	Magnesium sulphate	...	...	0·182	0·26	0·26	0·095	0·089
	Magnesium chloride	...	...	...	...	...	...	...
	Sodium bicarbonate	...	...	...	...	...	...	...
	Sodium carbonate	...	...	...	...	...	...	...
	Sodium sulphate	...	...	0·32	0·69	0·95	0·94	0·86
	Sodium chloride	...	...	0·0099	0·012	0·013	0·017	0·038

PHYSICAL CHARACTERS OF THE *CHOLAM* SOILS

Moreover, field observations of soils made during a number of seasons pointed out that the soils of a *cholam* field were hard to plough and cracked poorly in normal seasons and were more subject to the erosive forces of rains. They showed in addition a tendency to absorb rains more slowly and retain moisture for a longer period. These indicated a deterioration in aggregate formation. Laboratory investigations confirmed the deductions. The percolation studies showed that water passed through more slowly in the *cholam* soils than in those of *cumbu* plots, which became more appreciable with the increase in the number of leachings. The percolates from *cholam* soils were turbid and took more time for the setting of the soil suspensions. In addition the *cholam* soils were found to have higher soil dispersion coefficients than those of *cumbu* under similar conditions of moisture. These undesirable physical properties indicated reduction in pore space due to deterioration in the soil structure.

In the opinion of Russell [1938] such changes in the soil structure in the field would be accountable on the basis of changes either in the total clay

content or in the ionic composition. Both these aspects were studied. It was found that there was practically no change in the total contents of clay.

Studies in ionic contents

The soils at two depths were next analysed during three periods during the first year according to the methods outlined by Chapman and Kelly [1932]. The results indicated that the *cholam* plots contained more exchangeable soda than those of *cumbu*, and that soda increased with crop growth.

Table VIII (*a*)

Exchangeable soda in milli-equivalents per 100 gm. of soil

No.	Growth period	Average of all depths	Soil depths	Average of all crops and growth period	Average of all depths and growth period: *Irungu*	*Cumbu*	Fallow
1	Before the sowing of cereals, Sept. 1935	6·4227	1. Top 6 in.	5·2657	9·7046	7·6311	6·5954
2	The cereals 6 weeks old, Nov. 1935	8·0300	2. II 6 in.	5·1881			
3	At the shot blade stage of *cholam*, Dec. 1935	8·5247	3. III 6 in.	6·4619			
4	After the harvest of *cholam*, Feb. 1936	9·2380	4. IV 6 in.	10·3724			
5	Mid-summer—no crop period, June 1936	8·1100	5. V 6 in.	12·5971			
6	Before the sowing of cotton, Sept. 1936	7·8987					
7	When cotton was two months old, Dec. 1936	7·6147					
	Critical difference	1·240		1·035		0·791	
	Conclusions .	4, 3, 5, 2, 6, 7, 1		5, 4, 3, 1, 2	*Irungu* > *Cumbu* > Fallow		

Table VIII (*b*)

Values of exchangeable soda at depths between 12-18 in.

	Cumbu	*Cholam*	Fallow
	m. e.	m. e.	m. e.
1 Before the sowing of cereal in September .	2·85	4·00	3·91
2 When the crop was 6 weeks old . .	6·71	7·70	4·00
3 At shot blade stage.	8·03	8·32	5·10
4 At the time of harvest of cereals . .	8·46	10·08	6·09
5 Mid-summer (no crop period) . .	7·16	10·60	6·22
6 Before the sowing of cotton . . .	4·93	9·99	4·49
7 Two months after the sowing of cotton .	4·32	8·57	4·17

Conclusions on the average of *cumbu* and *cholam*— } 4, 3, 5, 2, 6, 7, 1 *Irungu* > *cumbu* > fallow

After pulse | After *cumbu* | After *cholam* fodder set seed

Growth of cotton

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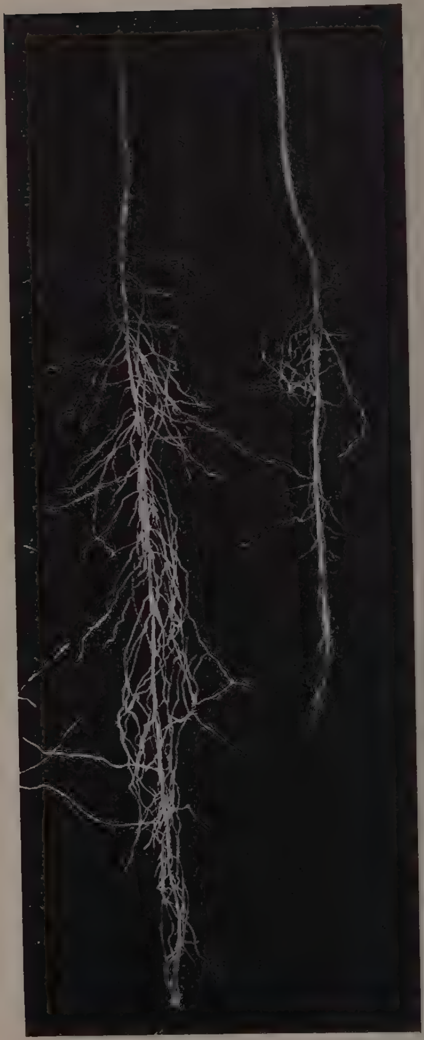
Soda in milli-equivalents 1·09 4·26 11·14

Fig. 1. Seedlings 13 days old



Gypsum treated Control (after *cholam* fodder set seed)

Fig. 2. Root-system in chimney culture

To elucidate this point further, soil samples were drawn during the next season from plots cropped with *cholam* and *cumbu* and also from fallow plots, at seven definite periods beginning with the fallow season prior to the sowing of the cereals and ending with the growing phase of the succeeding cotton. Estimations were made for the total exchangeable bases, calcium, magnesium, potassium and sodium ions. Very little differences were noticed in the total exchangeable bases, but a decrease in magnesium and a corresponding increase in the exchangeable soda was marked in the *cholam* soils. The data for sodium ion contents are summarized in Table VIII (*a*) and (*b*).

The sodium ion contents, especially those of the top third 6 in. layer, showed a characteristic pattern of ionic concentration varying with the time of analysis. Samples taken just prior to the sowing of cereals exhibited no significant differences between the plots. But in November, when the crops were six weeks old, their soils showed higher soda contents than the fallow. At the time of *cholam* harvest, they reached the maximum concentration. In June next, the soda contents started to decline. By September, just before the sowing of cotton, *cumbu* plots recorded a greater fall than those of *cholam*. When the cotton crop was two months old, *cumbu* plots contained exchangeable soda only as much as in fallow plots, while the *cholam* plots continued to maintain a higher amount.

The well-marked physical conditions of *cholam* soils, viz. lower cracking earlier erodability, reduced percolation, higher dispersion values, and cloddy condition, all now found an acceptable explanation in the increased alkalinization exhibited by such soils. But one would be inclined to doubt whether after all the increase in the soda of the order of 3 to 4 m. e. (milli-equivalents) would cause a depression in the yield of cotton to the extent of 16 per cent. But the consistency of the observations during more than one season gave it the strength of real existence. Further, evidences from other experiments conducted on the efficiency of small increments in sodium content on causations of appreciable changes in physical conditions of soils also became available. When cotton seedlings were raised in soils differing in replaceable sodium contents, pronounced differences in the development of root-systems were noticed even when the differences in sodium contents were as small as those observed between 'after *cumbu*' and 'after *cholam*' plots (Plate IV, fig. 1). The development of lateral roots was inhibited to a greater extent when the soda contents in the soil were higher. Apart from the above, Ratner [1935] found that an increase of 5·1 milli-equivalents in replaceable sodium affected considerably the physical properties of the soil in pots and concluded that the deleterious effect of exchangeable soda might be perceptible in practice in soils even with lower amounts than under the conditions of pot culture. Profile studies of the soils at Koilpatti (Table VII) pointed out that sulphates of calcium, magnesium and sodium were present to a higher degree from 2 to 6 ft. depths and that the concentration of sodium sulphate at depths below 3 ft. 6 in. was above 0·75 per cent limit of tolerance given by Hilgard [1936] for the growth of agricultural crops in heavy soils. Dastus [1938] found that concentrations of 0·08 per cent and upwards in sodium salts

proved harmful to cotton. The soil profiles at $4\frac{1}{2}$-6 ft. depths at Koilpatti showed higher concentrations than this limit. The surprise was that a fairly good growth of cotton and heavy yields of *cumbu* were obtained in these soils despite the high concentration of injurious salts. Possibly large quantities of gypsum met with in the lower layers of these soils reduced the harmful effects to a considerable extent.

It may, however, be pointed out that certain lacunae still exist for a complete understanding of the phenomenon on the basis of the above observations. The two facts that the *cholam* effect lasts for a single season and that the sodium when once it enters the soil complex is not easily removable, particularly under arid conditions, are not reconcilable with one another. The data on the exchangeable composition of the soils and its periodical changes do show the desired reversal of the sodium increase, but they need further confirmation. Final conclusions on this point should wait till more light on the rational mechanism for the reversal phenomenon is obtained.

Trial of correctives

The evidences of soda being in excess in the soils cropped with *cholam* suggested the application of correctives generally used to reclaim alkaline soils. When they were actually tried for two seasons on both *cholam* and cotton crops, the results indicated that none of them were really effective against the *cholam* effect under the conditions tested (Table IX).

Table IX

Effect of correctives on cotton yield

	Weight of seed cotton per acre (lb.)	
	Manuring done directly to cotton, 1936-37	Manuring done to the previous *cholam*, 1937-38
No fertilizer	261	599
Magnesite	199	600
Magnesite *plus* sulphur	228	608
Magnesium sulphate	241	569
Magnesium sulphate *plus* sulphur	211	566
Gypsum (local deposit)	284	599
Gypsum *plus* sulphur	234	625
Sulphur	222	629
Critical difference	46	65

The effect of molasses, which has been declared to be a good corrective for alkalinity by Dhar [1936], was studied for two seasons. In one season when the *cholam* effect was not perceptible, the incorporation of molasses increased the yield of seed cotton distinctly, but in the second year when the *cholam* effect was evident, the application did not induce any distinct response (Table X). The divergence in the results coupled with prohibitive cost of the molasses did not encourage further trials.

TABLE X

Effect of molasses on the yield of cotton seed

	Yield of seed cotton in lb. per acre	
	1936-37	1937-38
No molasses	263	709
Molasses	383	661
Critical difference	94	82

It was, however, made clear that the failure of the correctives to improve the *cholam* effect should not be taken as an indication of the non-existence of alkalinity in such soils, because when such soils were mixed with gypsum and used for raising cotton seedlings in chimneys, the root development was as good as in *cumbu* soils (Plate IV, fig. 2). The absence of response to the correctives under field conditions should be deemed to be due to the operation of unfavourable factors. Unfortunately the last three seasons, when the manures were tried, had erratic rainfall, with the result that the rains received at one time were not sufficient to carry the correctives down to the layers where the injurious alkaline salts were actually present.

TRIAL OF ALTERNATIVE FODDERS

Trials were also made to find out whether the *cholam* crop—the cause of the trouble—could be replaced by more beneficial crops. Several varieties of legumes, teosinte and *cumbu* were tested, but none of them succeeded to give as much fodder as was provided by the *cholam*. Different varieties of *cholam* were also compared. Their tonnage and palatability too were far behind those of the *irungu* variety grown in the tract. Harvesting *irungu cholam* at shot blade stage did not engender the injurious after-effects ; but that practice could not be adopted for two reasons. Firstly it provided only two-thirds of the fodder supplied by harvesting it at seed. Secondly the period of harvest synchronized frequently with wet weather which did not permit the drying of the stalks.

OTHER DEVICES

The beneficial effects of legumes on non-legumes grown in association with them were then sought to be utilized to minimize the *cholam* effect. The effect of the mixing of several pulses with *cholam* as well as with cotton were tested. In all the trials, the harmful after-effect of *cholam* continued to persist. In certain cases, associated cropping, like mixing black gram (*Phaseolus mungo*) with cotton, proved injurious.

Concurrently attempts were made, taking the clue from the normal agronomic practice of using a higher seed rate in crops to be grown in fertile and deteriorated soils, to test the efficacy of thick sowing of cotton on *cholam* effect. In all the three years of trial, distinct increases in the yield of seed cotton were obtained as a result of this practice (Table XI).

TABLE XI

Yield of normal and thick-sown cotton

	Yield of seed cotton in lb. per acre		
	1934-35	1935-36	1936-37
Normal sown .	422	258	236
Thick sown . .	495	286	259
Critical difference .	55	77	16·1

There was uniformity in the response to thick sowing, both in good and droughty years. This practice of using 15 lb. of seed rate in the place of 10 lb. used at present in the sowing of cotton could therefore be recommended for adoption on all fields cropped with *cholam*.

Mosseri [1931] stated that the absence of alkali troubles in the stiff clay soils of Egypt was due to the observance of summer fallow which permitted the land to crack widely and the deleterious salts to be deposited in the form of encrustations on the outside of clay particles, and that these salts were later on washed down by the heavy irrigations. This suggested that the general practice of the farmer of the 'Tinnies' tract to plough the land six to eight times prior to the sowing of cotton would have prevented the soils from cracking widely and from forming encrustation of the salts on the soil particles. Experiments were conducted to study the effect of keeping the land unploughed till the sowing of cotton. The results obtained during four seasons (Table XII) pointed out that the yields in 'not-ploughed' plots were only as good as those that were ploughed.

	Yield of seed cotton in lb. per acre			
	1934-35	1935-36	1936-37	1937-38
Ploughed	450	244	396	522
Not ploughed	453	302	380	505
Critical difference ($P=0\cdot05$)	81	38	18·9	65

These observations, though they did not conform to expectations based on Egyptian experience, were useful to show that some of the preparatory operations could be dispensed with, reducing thereby the cost of cultivation of cotton, which would be an indirect gain to the farmer.

Summary

The results obtained may be summed up thus :

(*a*) The diminished yield of cotton obtained in the tract on fields cropped with *cholam* during the previous year is found to be caused neither by lack of soil moisture, nor by exhaustion of soil nutrients, nor by the presence of toxic products of decomposition.

(*b*) The harmful effects could not be improved by the application of manures, the reduction of plant population or by mixing *cholam* with pulses.

(*c*) Seed setting and duration of *cholam* were observed to influence the intensity of the deleterious effects of *cholam* cropping, since the *cholam* effect was not manifest in the crop cut at shot blade. This phenomenon could be ascribed to the normal penetration of the *cholam* roots into the alkaline regions of the soil below the second foot.

(*d*) The growing of both *cumbu* and *cholam* disturbed differently the sodium ion contents of the soil. In soils cropped with *cholam*, the rise of replaceable sodium was greater with the growth of crop, but its later decline was much slower than that observed in the case of *cumbu* plots. As a consequence former soils were left more alkaline at the time of cotton sowing, which condition would appear to be responsible for the lower yields recorded after *cholam* crops.

(*e*) Correctives for alkalinity could not give conclusive results owing to unfavourable seasonal conditions. It was however inferred that their application in the lower layers might show better response.

(*f*) *Cholam* could not be replaced by other fodders.

(*g*) Ploughing experiments showed that these soils were not benefited by cultivating them prior to the sowing of cotton. A saving in the cost of cultivation might be effected by reducing the preparatory cultivation to the minimum.

(*h*) Thick sowing of cotton improved the yields of cotton in 'after *cholam*' plots, both in good and poor seasons of rainfall.

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*A PRELIMINARY NOTE ON THE EFFECT OF ENVIRONMENT ON THE QUALITY OF PUNJAB-AMERICAN 289F/43 COTTON

BY

S. RAJARAMAN

AND

MOHAMMAD AFZAL

Cotton Research Laboratory, Lyallpur

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INTRODUCTION

THE Punjab-American 289F/43 is a selection from a strain 168F produced by Milne. In 1925, one off-type plant was selected from this strain. This plant proved to be a natural hybrid and during 1926 to 1933, several progenies of this plant were under observation and trial. These progenies while differing in minor morphological characters, had several very desirable features in common. The most notable of these were early-maturing habit, good opening of bolls and long lint. After careful field trials the present strain was selected for general propagation in 1934. The area under this strain expanded very rapidly and in 1938-39 it was estimated to be about one lakh of acres, chiefly in the Lower Bari Doab Canal Colony and the inundation tracts in the south-west of the province.

289F/43 is a very drought-resistant and high-yielding variety, the lint of which has been adjudged, at the Technological Laboratory, Matunga, Bombay, as capable of spinning up to 35/40 standard warp counts spun with medium twist in different years. The samples for these spinning tests have all been drawn from the produce of the seed multiplication area at the Cotton Research Farm, Risalewala, where the crop is grown under very good conditions and expert supervision. The seed produced at this farm is then grown at the Seed Farm, Risalewala, where also the crop is carefully rogued and the ginning of the *kapas* is carried out at the experimental ginnery where there is no chance of seed contamination. The seed so produced is passed on to the big estates, where also some control is exercised by the Punjab Department of Agriculture. The ginning at this stage is, however, done in commercial ginneries. This seed is purchased by the Agricultural Department for sale to the cultivators. Thus it will be seen that there are four distinct stages of propagation of this vareity, viz. the seed multiplication area at the Cotton Research Farm, Risalewala, Seed Farm, Risalewala, the big estates and the general cultivator. While there is rigid control during the first two stages and partial control during the third stage, no control whatever is possible when the seed passes on to the cultivators of the province. From the point of view of the trade, however, the crop produced by the cultivators is the most important as by far the biggest

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bulk of the supplies of cotton which finds its way into the various channels of trade comes from them. It was, therefore, considered desirable to find out the variations, if any, in the fibre properties of 289F/43 as it passes on from one stage of propagation to another and also the effect of environment during the fourth stage.

It is well known that the quality of lint of the various pure strains in the Punjab varies with the locality of growth. The present investigation, therefore, assumes an additional importance, as it will provide some very useful information to the trade.

Previous literature

Turner [1929] carried out a large number of spinning tests on Punjab-American 4F and 289F and the improved Mollisoni grown in different parts of the province. The spinning performance in terms of highest standard warp counts of these cottons varied from 16's to 24's for 4F, from 38's to 44's for 289F and from 5's to 8's for Mollisoni. Barre [1938] carried out what he called a regional variety study and planted 16 varieties of cotton from the same seed-stock at 14 places across the cotton belt of the United States of America and seven varieties at four localities in the irrigated tract of the south-west for three years in succession. He found that there was seldom more than 1/8 inch difference in staple length of any particular variety when grown in the Mississippi Delta under optimum moisture conditions or when grown under the extremely arid conditions of 1935 in Oklahoma and west Texas. From his extensive data he concluded that inheritance and soil moisture were the two factors determining staple-length and that inheritance was the more important of the two.

Material and methods

For the purpose of the present investigation, the crop raised at the Cotton Research Farm, Risalewala, represents the first stage of propagation, that raised at the Seed Farm, Risalewala, the second stage and that from Sardar Bahadur Sardar Ujjal Singh's Farm, Mian Channu, the third stage. The following 12 places scattered all over the Canal Colonies and the inundation tracts of the south-west were selected as being representative of the fourth stage :

(i) Chiniot
(ii) Khanewal
(iii) Kot Adu
(iv) Okara
(v) Shorkot
(vi) Vihari
(vii) Jhang
(viii) Sangla Hill
(ix) Mithalak Stud Farm, Sargodha
(x) Montgomery
(xi) Sargodha
(xii) Nankana Sahib

The samples were collected in 1936 and *kapas* from the middle picking of 25 plants each from the first and the second stages, 50 plants from the third stage and 10 plants from each of the 12 places of the fourth stage was picked separately for each plant. The *kapas* from each plant was ginned very carefully with the laboratory hand roller gin and the lint was tested for the following characters :

(i) Mean fibre-length,

(ii) Mean fibre-weight per unit length at 70 per cent relative humidity, and

(iii) Fibre maturity.

The mean fibre-length was determined with Ball's Sledge Sorter [1921], The mean fibre-weight per unit length, which is a measure of the fineness of staple, was obtained after the whole fibre method of Ahmad [1933]. The fibre maturity was determined according to the method described by Gulati and Ahmad [1935], and for this purpose the fibres were mounted on the ' maturity slides ' devised by Ahmad and Gulati [1936].

Experimental results

The results obtained were analysed statistically by Student's *t*-method for determining the significance or otherwise of the differences in the averages of the lint characters between the first and the other stages. As some of the samples received from 11 out of the 12 places in the fourth stage were not found to be typical of 289F/43 (probably due to admixture with seed of other varieties in commercial ginneries), the analysis was carried out in two stages. One in which all the samples were considered irrespective of the variety to which they belonged and the other in which only those samples as belonged to 289F/43 were considered. The results obtained are shown in Table I.

Conclusion

This preliminary study of the problem has revealed certain very interesting features, and it was, therefore, considered desirable to bring these results to the notice of other workers on cotton in India. It is thought that similar studies made on other commercial varieties of cotton will prove very useful not only to the worker in the laboratory but also to the members of the trade. The conclusions are as follows :

(*a*) The average mean lengths and percentages of mature fibres for samples from the second and the third stages were significantly higher than for samples from the first stage, while the average mean fibre-weights per unit length were not significantly different from one another. This showed that the fibres in the second and the third stages were finer than those in the first stage since there was no significant difference in mean fibre-weight per unit length in spite of a significant increase in maturity.*

*At a conference held in Bombay, Dr Nazir Ahmad suggested an alternative possibility that the constancy of the fibre-weight might be due to a change in the distribution of the percentages of mature, half-mature and immature fibres. The results were studied with this suggestion in mind, and it was found that the above conclusions were still true.

TABLE I

STAGE	No.	PLACE OF ORIGIN	ALL SAMPLES							SAMPLES OF 289F/43 ONLY						
			No. of samples	Average mean length (cm.)	Difference from the first stage	Average mean fibre-weight* (10^{-6} gm.)	Difference from the first stage	Average percentage of mature fibres	Difference from the first stage	No. of samples	Average mean length* (cm.)	Difference from the first stage	Average mean fibre-weight* (10^{-6} gm.)	Difference from the first stage	Average percentage of mature fibres	Difference from the first stage
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
I	1	Cotton Research Farm, Risalewala	25	2·3112	...	1·6628	...	60·104	...	25	2·3112	...	1·6628	...	60·104	...
II	14	Seed Farm, Risalewala	25	2·404	—0·0928†	1·6532	0·0096	67·548	—7·444†	25	2·404	—0·0928†	1·6532	0·0096	67·548	—7·444†
III	15	Sardar Bahadur Sardar Ujjal Singh's Farm, Mian Channu	50	2·445	—0·1338†	1·705	—0·0422	64·88	—4·776**	50	2·445	—0·1338†	1·70	—0·0422	64·88	—4·776**
IV	2	Chiniot	10	2·345	—0·0338	1·863	—0·2002†	64·4	—4·296	6	2·326	—0·0155	1·923	—0·2605†	64·816	—4·713
IV	3	Khanewal	10	2·476	—0·1648†	1·820	—0·1572†	69·6	—9·496†	5	2·444	—0·1328†	1·916	—0·2532†	73·26	—13·156†
IV	4	Kot Adu	10	2·132	0·1792†	1·801	—0·1382**	58·17	1·934	8	2·115	0·1962†	1·850	—0·1872†	58·55	1·554
IV	5	Okara	10	2·161	0·1502†	1·944	—0·2812†	65·82	—5·716	4	2·092$_6$	0·2187†	2·010	—0·3472†	64·775	—4·671
IV	6	Shorkot	10	2·243	0·0682**	1·727	—0·0642	62·6	—2·496	9	2·24	0·0712**	1·714	—0·0516	62·24	—2·136
IV	7	Vihari	10	2·241	0·0702†	2·028	—0·3652†	71·36	—11·256†	7	2·205$_7$	0·1055†	2·075$_7$	—0·4129†	74·436	—14·382†
IV	8	Jhang	10	2·295	0·0162	1·845	—0·1822†	66·46	—6·354	5	2·334	—0·0228	1·678	—0·0152	68·78	—8·676**
IV	9	Sangla Hill	10	2·408	—0·0968†	1·908	—0·2452†	70·55	—10·446†	6	2·405	—0·0938†	1·806	—0·1439**	67·6	—7·496**
IV	10	Mithalak Stud Farm, Sargodha	10	2·334	—0·0228	1·561	0·1018**	47·94	12·164†	7	2·318$_6$	—0·0074	1·524$_2$	0·1385**	48·629	11·475†
IV	11	Montgomery	10	2·366	—0·0548	1·873	—0·2102†	67·2	—7·096**	6	2·311$_6$	—0·0005	1·830	—0·1672†	64·6	—4·563
IV	12	Sargodha	10	2·284	0·0272	1·542	0·1212**	51·05	9·054**	8	2·261$_2$	0·0499	1·545	0·1178**	49·587	10·516**
IV	13	Nankana Sahib	10	2·319	—0·0078	1·707	—0·0442	64·14	—4·036	10	2·319	—0·0078	1·707	—0·0442	64·14	—4·036

*At 70 per cent relative humidity
**Significant at 5 per cent level
†Significant at 1 per cent level

(*b*) The samples from the Mithalak Stud Farm and the *zamindari* farms at Sargodha were somewhat exceptional in that they possessed low maturity with correspondingly low mean fibre-weights per unit length as compared with the samples from the first stage even though the mean lengths were not significantly different from one another. These results fit in with the agricultural field trials which have shown that this part of the Lower Jhelum Canal Colony is not suitable for the growth of 289F/43. These samples were not, therefore, considered further.

(*c*) The average mean fibre-weights per unit length and percentages of mature fibres for samples from the remaining 10 places were all greater than for samples from the first stage. Samples from Kot Adu were an exception to this general observation since the percentage of mature fibres was not significantly different. Of these 10 places, samples from Chiniot, Khanewal, Sangla Hill, Montgomery and Nankana Sahib possessed a greater average mean length. Those from Kot Adu, Okara, Shorkot, Vihari and Jhang were shorter in staple. Of the former five places, samples from Khanewal and Sangla Hill only were significantly longer, while of the latter five only those from Kot Adu, Okara, Shorkot and Vihari were similarly shorter.

The most interesting part of these observations is brought out here. For samples from Kot Adu and Okara, the percentage of mature fibres was not significantly different from that for the first stage ; and a significant decrease in their staple-length was accompanied by a significant increase in their mean fibre-weight per unit length. In this case it seems that the environmental conditions obtaining were rather unfavourable for an increase in the length of the fibre, but were favourable for an increase in the mean fibre-weight per unit length. Since the percentage of mature fibres practically remained the same, the effect of the increase in mean fibre-weight per unit length was to make the lint coarse.

For samples from Khanewal and Sangla Hill, there was a significant increase in fibre maturity over the first stage ; and a significant increase in the staple-length of these samples was still associated with a significant increase in their mean fibre-weight per unit length. It is apparent that the conditions which prevailed here had been favourable not only to an increase in the staple-length but also to increases in the mean fibre-weight per unit length and maturity. Since the increase in mean fibre-weight per unit length was associated not only with an increase in maturity but also with an increase in staple-length, it is highly probable that the lint in this case was finer.

The samples from Vihari were further characteristically different from the rest in that a significantly large increase in maturity, combined with a large decrease in staple-length, resulted in a large increase in mean fibre-weight per unit length. In this case the lint had apparently grown very coarse.

(*d*) These results indicate that the lint of 289F/43 from the fourth stage showed a tendency, in general, towards coarseness when compared with the lint from the first stage, excepting the samples from Khanewal and Sangla Hill, where the lint either continued to be of the same fineness as that of the

first stage, or more probably was of greater fineness. The staple-lengths of these samples are ranged equally on both sides of the value for the first stage while the fibre maturity is uniformly higher excepting for a non-significant decrease in samples from Kot Adu.

Summary

The propagation of the Punjab-American cotton 289F/43 was divided into four stages and the effect of stage of propagation on the quality of lint was traced from stage to stage. It was found that the staple-length and maturity of lint from the second and the third stages showed an improvement over those of the first stage, while the mean fibre-weight per unit length was almost constant. This improvement was not maintained in the samples from the fourth stage excepting those from Khanewal and Sangla Hill.

Acknowledgements

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SURVEY OF COTTONS IN BALUCHISTAN

BY

M. A. A. ANSARI

Institute of Plant Industry, Indore, Central India

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(With Plates V and VI)

Introduction

THE survey of the cotton areas in Baluchistan which includes portions, of the Mekran coast in the south and the north Baluchistan contiguous to Sind was financed by the Indian Central Cotton Committee. The tour began in the middle of August and lasted for about nine weeks.

It was found that Kathiawar ports imported *kapas* from the Mekran coast which is partly in Iran and partly in Baluchistan. Any restrictions imposed on the imports of cotton from Iran, to prevent the introduction of new pests and diseases to India, would have to be applied therefore for Baluchistan as well. Information on the Iran cottons had already been collected in a survey of the area undertaken three years previously [Ansari, 1940], and it was suggested that a similar survey of cotton-growing areas in Baluchistan should be carried out in order to collect information on the nature and extent of cotton cultivation in those areas.

Mekran

(A) Characteristics of cotton areas visited

According to information available, cotton was reported to be grown in the valleys of Dasht, Kech and Kulanch in Mekran, and Nasirabad Tehsil, Sibi, Kachhi Division of Kalat State and Nushki Tehsil in North Baluchistan and the survey was confined to these tracts.

Method of survey

The types of cotton and their morphological characters were noted. Since the identification of the diseases and pests present was an important consideration in the survey, census of the diseased plants was taken by taking 10 random fields in each area and counting the diseased plants in the first 100 in each of the field. Since the number of plants taken formed only about 2 to 3 per cent of the total population in a field, the size of the sample may be considered inadequate, but still it should give an idea of the diseases present. In order to have an idea of the quality of the cotton grown, *kapas* from 10 random plants from each of the fields visited was picked. Small bulk samples of 1 to 2 lb. from the *kapas* picked by the cultivators and left in heaps in the fields were also taken so as to have a larger quantity of material for

examination (Plate V). The total number of single plant samples and bulks thus obtained was about 400. Herbarium specimen of diseased plants, specimens of insect-attacked leaves and bolls and also soil samples from each of the fields visited were brought for examination.

Entry into Mekran was made at Gwadar, a port on the Mekran Coast and administered by the Sultan of Muscat. After surveying the valleys of Dasht, Kech and Kulanch the return was made through Pasni. The Kolwa valley was left out since no cotton was reported to be growing there. The whole journey of about 500 miles was done on camels, and the route followed is shown in the map (Plate VI).

Nature of the country and the cotton areas en route

The cultivated area is very scattered. In Dasht area the cultivation is found in and around Garouk and from Suntsar to Kuntdar, and in Kech from Bugdan to Turbat and as far west as Mand. In Kulanch, the areas comprising Nokbur, Zahreen-Kahur and Sardasht are extensively cultivated. It is difficult to give an idea of the acreage under cotton. The lands have not been measured and, besides, cotton is sown as a mixed crop along with *jowar* (*Andropogon sorghum*) and pulses. All that can be said is that the total cultivated area would be about 170 sq. miles, i.e. about 1,08,800 acres, 48 per cent of which would be in Dasht, 34 per cent in Kech and 18 per cent in Kulanch.

The important soils met with in Mekran can broadly be classified into the following :

Milk is a soft and white clay. Having been brought down from the hills and deposited by the streams and hill torrents, it is reputed for its fertility. It is friable, can absorb water quickly and is known to retain moisture for a longer time than the other kinds of soil occurring in Mekran.

Gach is a bluish white clay. Unlike *milk*, it is said to become hard and uncultivable after two or three years, and therefore is left fallow for some period to regain its good properties. It seems to be well adapted for cotton as the plants in *gach* soil appeared to be more luxuriant than in any other soil.

Mat is a silt. Although liable to crack, it is considered to be superior to *milk*. Lands which have received deposits of *mat* once or twice are known as *bug*.

Rek or *zawar* is considered inferior to *milk* only as it takes moisture easily and the sub-soil retains it well. It is extremely well fitted for rice.

Dalo is fragmentary and is composed of rubble and *milk*. It is found in fields excavated in hill-sides along the beds of rivers.

Pat is a hard and white clay. It is compact and does not allow moisture to go deep into it.

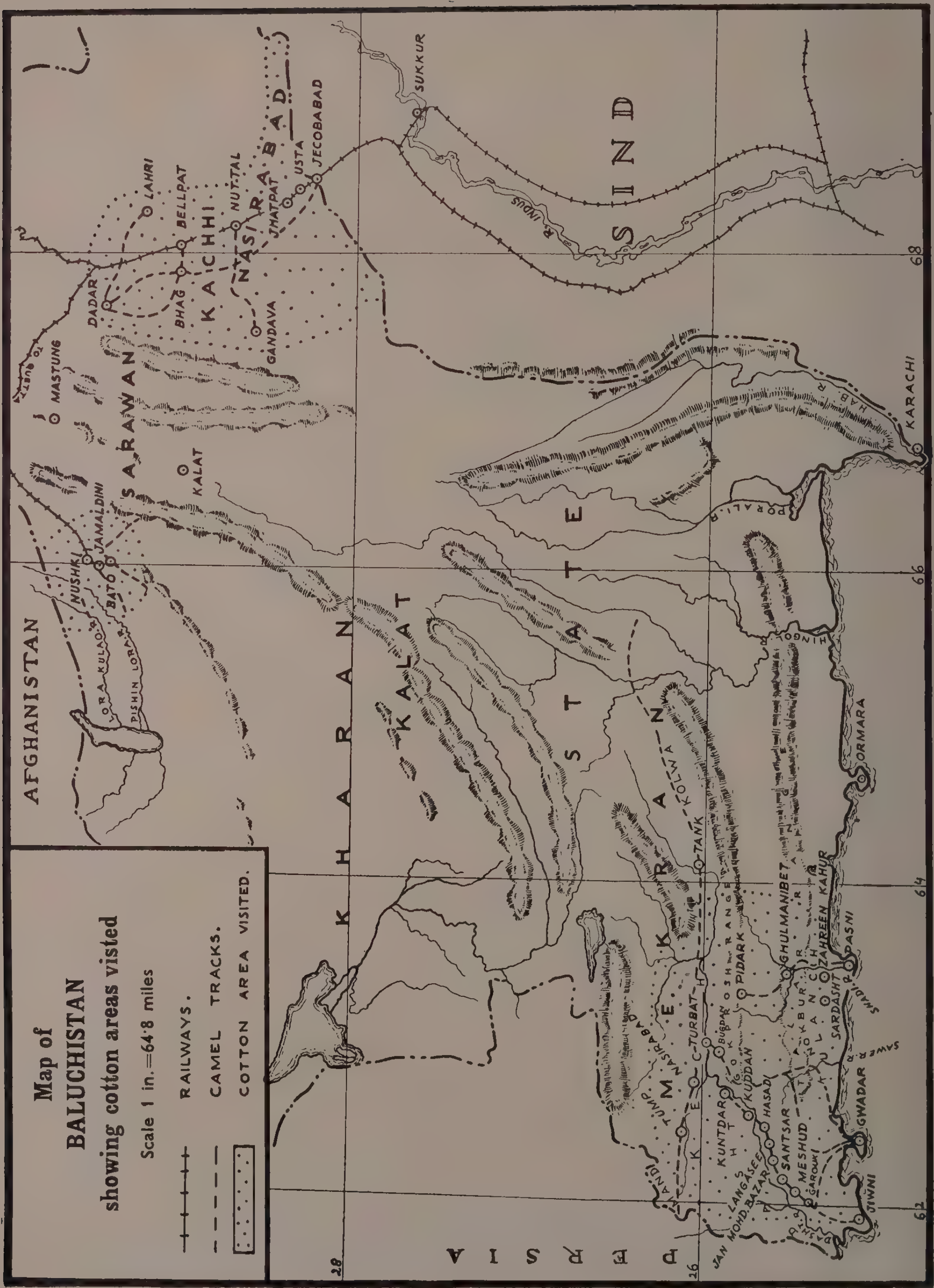
Dasht has *milk* and *gach* types, Kech, *rek* and *dalo* types while Kulanch, *milk*, *rek* and *pat* types of soil.

Climate and rainfall

The climatic conditions of Dasht and the Kulanch valley are almost the same. For the greater part of the year the climate is hot and oppressive.

FIG 1. Picking single plants in a field at Kuddan (Dasht, Mekran)

FIG. 2. Taking bulk samples from a heap amassed by the owner of the field (Dasht, Mekran)


Map of
BALUCHISTAN
showing cotton areas visted
Scale 1 in.=64·8 miles
RAILWAYS.
CAMEL TRACKS.
COTTON AREA VISITED.
AFGHANISTAN
PERSIA
SIND
KHARAN
KALAT
STATE
SARAWAN
KACHHI
NASIRABAD
MEKRAN
KOLWA
KECH
MASTUNG
KALAT
DADAR
BHAG
GANDAVA
BELLPAT
LAHRI
NUT-TAL
JHATPAT
USTA
JECOBABAD
SUKKUR
R. INDUS
NUSHKI
JAMALDINI
BATO
LORA
KULAO
PISHIN LORA
HAB. R.
KARACHI
PORALI. R.
HINGOL
ORMARA
PASNI
GWADAR
JIWANI
TURBAT
TANK
PIDARK
GHULMANIBET
ZAHREEN KAHUR
SARDASHT
SHADI
SAWE R.
KUDDAN
HASAD
SANTSAR
MESHUD
KUNTDAR
LANGASEE
JAN MOHD.BAZAR
NASIRABAD
TUMP
MANDI
28
26
62
64
66
68

Kech is the hottest of all the three tracts, temperature during July going as high as 113°F. All along the journey in Kech the scorching north wind locally known as *gorich* was experienced. Between November and January, however, the climate is cool and pleasant all over. The rainfall is uncertain and capricious and the country is liable to long periods of drought. In summer it rains between May and September and in winter between February and March. Summer rains are more important, and drought in summer cannot be compensated for by copious rains in winter. The average of temperature and rainfall at Pasni from 1934 to 1937, as calculated from the data obtained from the Locust Research Assistant, Pasni, is given below :

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Aver.
Temperature	61·2	66·6	71·1	77·2	82·0	85·3	84·6	81·7	79·0	77·4	72·3	67·1	75·5
	±44·6	±43·6	±44·2	±44·2	±42·4	±40·1	±37·2	±37·6	±39·2	±43·5	±45·1	±43·0	±42·1
Rainfall (inches) :	2·035	1 385	0·250	0·115	0·125	nil	0·052	nil	0·005	0·017	0·015	0·797	0·399

Crops

The important autumn crops in Dasht and Kulanch are cotton, *jowar sohro* (an inferior kind of *jowar* with red grains), *mung* (*Phaseolus radiatus*) and *arzan* (*Panicum miliaceum*), while the spring crops are wheat and barley. In Kech, however, cotton is a minor crop and greater attention is paid to the cultivation of rice and *jowar*. Date forms a very important crop in Kech and Kulanch villages. *Jowar* straw and lucerne are the chief fodder.

Type of cotton

The type of cotton met with all along Mekran is *G. herbaceum* var. *typicum* [Hutchinson and Ghose, 1937]. There is a great variation in the size of the bolls and the number of loculi per boll on the same plant. The plants were mostly shrubby, 4-8 ft. high ; habit mainly sympodial with three to five strong vegetative branches. Stems strongly pigmented (grades 1 and 2 [Hutchinson, and Ramiah, 1938]). Stems, petioles and pedicels sparsely hairy. Leaves leathery, usually flat with divergent lobes and open sinuses. Red spot, nectaries on main nerves. Bracteoles broadly triangular, broader than long, slightly to strongly cordate, margins divided into six to eight broadly triangular teeth. Flowers yellow with a deep red spot at the base. Bolls 1 in. to $1\frac{1}{4}$ in. long, rounded, beaked, surface shallowly dented, green and opening widely when ripe (grade 1 [Hutchinson and Ramiah, 1938]). Lint white or grey. Seeds small, fuzz uniformly distributed over the seed (grades 5 to 7 [Hutchinson and Ramiah, 1938]). In Ketch, the plants also vary in colour from dark green to pale green and in Ootjoo (Tump area), there was found to be an isolated patch of dark green plants which were clearly distinguishable in colour from the pale green ones of the neighbouring fields. There is no other morphological difference between them. In halo-length and ginning percentage the pale greens are found superior to dark greens. I was told that these two kinds of plants usually occur intermixed. The pale

greens are known locally as *zard-i-pusht* and the dark greens as *siah-i-pusht*. In Kech, the crop is late and only about 60 gm. of *kapas* from each of the pale greens and dark greens could be obtained.

(B) Agricultural conditions and pests and diseases

Under normal conditions cottons are sown between February and March. but due to uncertainty of rains this period is not rigidly followed. Wheneve, there aré rains whether in summer or winter, cotton seeds are dibbled. Ir Kech, it is sown for the sake of rotation only or if some land is left over aften sowing rice and *jowar*. In irrigation also, first attention is given to rice anr, *jowar*. It is therefore usually sown a fortnight or a month later than in Dashtd i.e. in April or May.

Excepting in Kech, where cotton may be seen as a pure crop, it is sown all over Mekran as a mixed crop, usually with rows of *jowar*, *sohro*, *mung* or *mash* in between. Three to ten cotton seeds are dibbled at each point by hand, in furrows, distance between the holes and that between the rows of cotton varying from 5 to 10 ft. *Jowar* and pulses are sown by a funnel-shaped *nai* made of date palm leaves and attached to the handle of a single-shared plough.

Excepting in Kech, where *karezes* provide permanent source of irrigation, cottons all over Mekran depend entirely on rain-water or flood irrigation. It is allowed to stay in the field even up to six years. In years of no rainfall, however, there is no alternative than to ratoon the crop. Due to the more luxuriant growths of *sohro*, the growth of the cotton plant is retarded in the beginning. At the time of the *sohro* harvest, it is hardly about 2 ft. high After the *sohro* harvest, it grows faster.

Flowering and picking

The period of flowering varies from May to June and the boll formation takes place 10-15 days after flowering. The priod of picking lasts from the end of July till October.

Yield

The lands in Mekran have not been measured and, therefore, no records are available regarding the yield of *kapas* per acre. Usually four pickings are done in each season and from what I observed can say that with a seed rate of only 2 to 3 lb. per acre, the yield of *kapas* varies from 150 to 400 lb.per season. I was told that in the first year the yield is small but lint is of the best quality, locally known as *nihali kapas*. In the second and third years the yield is the highest. The month of September gives the largest yield. Dasht area yields about 56 per cent of the *kapas* produced in Mekran, Kech 10 per cent and Kulanch 34 per cent.

Pests and diseases

The pests and diseases common in Mekran were the pink bollworm, spotted bollworm, dusky cotton bug, white-fly, plant lice and stenosis. They have since been confirmed by the reports received from the Imperial Mycologist and the Imperial Entomologist, Delhi, to whom specimens of diseased bolls and

plants were sent for identification. Out of the three valleys visited Kulanch suffered heavily. The statistical examination of the diseased plants (cf. Method of survey, above) showed that while there were no significant differences in the incidence of diseases from field to field, there were sharp differences in the intensity of the different diseases. Out of a total of 31·5 per cent of the diseased plants those suffering from stenosis alone amounted to 14·5 per cent. The remaining 17 per cent suffered from bollworms and white fly. In Dasht and Kech, pink bollworm, white-fly and dusky cotton bug are found on cotton plants, but the damage done was negligible.

In Tump (Kech area), I was informed by the local Revenue Officer that in certain seasons there the cottons suffer from a particular disease known as *sheergoo* so-called because a sort of sweet sticky substance, *shira*, is found on the plant body. Inside the *shira* are to be found insects round and green in colour. The plants suffer at any stage of their growth but usually at maturity, with the result that they gradually turn black and die. I did not see the disease but, from what I am informed, it may be probably due to plant lice.

(C) Production of cotton

Only a negligible amount of cotton produced in Indian Mekran is used inside the country for making quilts and fish nets. Due to the import of cheap cloth from foreign markets, home-made cloth is practically non-existent. The khaki cotton industry, the cloth of which is very much liked by the people, has almost died out. Preparation of rugs and *dari* stitching has practically ceased to exist.

There are no ginning factories in Mekran. The merchants at Gawadar and Pasni lend money to the cultivators and get *kapas* from them in return at the rate of Rs. 2-8 to Rs. 8 per maund. The ginning out-turn is about 28 per cent. These cottons, after ginning in Kathiawar, fetch Rs. 18 to Rs. 40 per maund. Before the prohibition of the import of unginned cottons to Kathiawar ports was passed, almost the whole of the *kapas* produced in Indian and Iranian Mekran used to be sent to Cutch and Kathiawar. The enforcement of the prohibition has had a marked check on the export of cottons from these parts to India. I could see over 4,000 mds. of *kapas* in Gawadar and about the same quantity in Pasni lying in stock with the cotton merchants for the last two years. It is difficult to give an exact figure for the total amount of *kapas* produced in Mekran and that exported. The lands had not been measured and records for the total produce of the country were not kept. Kalat State appraises one-tenth of the total produce of *kapas* as revenue, and the figures which are available for the last 10 years are given in Table I.

Ten times of the above figures would give an idea of the produce on which revenue is charged, while there were about 40 per cent of the lands which, being *muafiyat*, were exempted from revenue and for the produce of which, therefore, no records were available.

It will be seen from Table I that the year-to-year figures exhibit great variation. After excluding the years 1932-33 and 1933-34, which give exceptionally low and high yields respectively, the average per year would be

4,300 mds. If 40 per cent of the exempted *kapas* is added to the above, the average per year will increase to 7,166 mds.

TABLE I

One-tenth of the produce appraised us revenue in mds.

Year	Areas			
	Dasht	Kech	Kulanch	Total
1928-29	201	13	129	312
1929-30	113	4	95	212
1930-31	93	25	221	339
1931-32	61	12	227	300
1932-33	41	45	41	127
1933-34	549	56	388	993
1934-35	344	10	24	378
1935-36	495	106	94	695
1936-37	368	93	299	760
1937-38	282	90	42	414
	2,547 56 per cent	454 10 per cent	1,560 34 per cent	4,560 100 per cent

The figures for the export of *kapas* from Pasni to India from 1935-36 to 1937-38 as supplied by the Port Officer, Pasni, are given below :

Year	Quantity of *kapas* exported in mds.
1935-36 . . .	9,120
1936-37 . . .	13,682
1937-38 . . .	4,749
Total . .	27,551

It will be seen that the average annual export is 9,183 mds. The figures for the export of *kapas* and the total produce of the country thus agree fairly closely.

Seth Bande Ali, the biggest cotton merchant at Gawadar, informed me that the yearly export of *kapas* from Indian and Iranian Mekran combined

varied from 21,625 to 33,935 mds. According to him, 56 per cent of this quantity is exported from Chabbahar Iranian Mekran and the remaining 46 per cent from Indian Mekran which comes to be 9,947 to 15,610 mds.

The soil of Mekran, particularly that of Dasht and Kulanch, is extremely well fitted for cotton. Without any manuring and agricultural operations after sowing the crop, yields between 150 to 400 lb. of *kapas* are obtained per season. Although Kulanch cottons at the time of my visit were suffering from diseases, the fact that there are immense possibilities of improving the cottons in Mekran needs no emphasis.

North Baluchistan

Soil

The soil all over the areas visited in North Baluchistan is chiefly alluvial and very fertile wherever water is available. The best is light loam mixed with a proportion of sand and is locally known as *mat*. It requires less water, retains moisture longer and is suited for all crops. The other kind is *khauri* or *reti* which, having more of sand, is very suitable for *jowar*. In Nushki particularly, a hard stony soil known as *daddo* and *sov* impregnated with salt are also found. Both of these are of inferior type.

Climate and rainfall

The climatic conditions of Nasirabad and Kachhi are very nearly the same. Rainfall is scanty, varying between 3 to 5 in. There are only two marked seasons, summer and winter, the former beginning from April and the latter from October. The temperature during April and October is very variable. In December and January—the coldest months—the temperature goes down to 27°F. The hottest months are June and July when at times the deadly *simoom* prevails. Kachhi is regarded as one of the hottest tracts in India.

In Nushki, there are four marked seasons, *hatam* or spring, from March to May, *tirma* or *bashasham*, i.e. the rainy season, between June and August, *sohel* or autumn, comprising September and October and *selt* or winter.

The average temperature for different seasons from September 1936 to September 1938 and the average yearly rainfall from 1928 to 1938 as calculated from the figures obtained from the Agency Office, Nushki, are given below :

Seasons	Average temp. (°F.)	Rainfall average per year (in.)
Spring	$78{\cdot}7 \pm 11{\cdot}9$	0·616
Rainy season	$96{\cdot}5 \pm 11{\cdot}9$	
Autumn	$88{\cdot}3 \pm 6{\cdot}1$	
Winter	$57{\cdot}4 \pm 7{\cdot}7$	

Type of cotton

In Nasirabad and Nushki, cotton has been introduced recently and is of the Punjab-American type obtained from Sind. The British Cotton Growing Association and the Agricultural Department, Baluchistan, both have their

stations in Usta Colony, Nasirabad. They are trying KT-23, KT-25, 43F 4F, 4F-98 and 45F (all Punjab-Americans) and N T 12 (Sind Desi) obtained from Sind. In Gandawa and Lehri out of a total of about 250 acres under cotton, only about 70 acres were under *herbaceums*, while the remaining were under Punjab-Americans. Sibi was all under Punjab-Americans.

Agricultural conditions of the cotton crop

The agricultural conditions in Nasirabad are like those of Sind. The tract enjoys the beneficence of the Kirthar branch of Sukkur barrage. In Kachhi, Sibi and Nushki, cotton cultivation depends on flood irrigation by rivers or permanent irrigation provided by *karezes*. In Kachhi and Sibi the floods generally occur in July and August and sometimes during the spring also. If floods occur in spring, i.e. March, cotton seed locally known as *kakri* is broadcast immediately after *jowar*. Sometimes *jowar*, melons and cottons are all broadcast. In Nushki, the sowing time is from February to March and picking is done between October and November. In 1936-37, there was a bumper crop and, due to scarcity of labour, half of the *kapas* was left unpicked. In 1937-38, fearing a waste of *kapas* again only about 100 acres were sown with cotton. The *herbaceums* found in this tract differed from the Mekran *herbaceums* in the following characters only : Stems green (grades 4 and 5 [Hutchinson and Ramiah, 1938]). Leaves with open or slightly rumpled sinuses. Bracteoles rounded, strongly cordate. Bolls opening moderately widely when ripe (grade 2 [Hutchinson and Ramiah, 1938]).

Pests and diseases of cotton

Herbaceums in North Baluchistan were practically free from diseases and pests. In Nushki, the Punjab-Americans suffered from bollworms and red-leaf to the extent of 1 to 2 per cent only. In Nasirabad and Gandawa the pests on Punjab-Americans were bollworms, plant lice and white ants and the incidence of disease was 21 per cent and 30 per cent respectively. The data obtained by the census of the diseased plants were statistically examined and it was found that, while difference in the incidence of disease from field to field was not significant at any one of the two localities, there were sharp differences in the intensity of various diseases, and the spotted bollworms and plant lice took significantly the heaviest toll at both these places. In Hazarwah (Nasirabad), several of the plots of Punjab-Americans sown by the British Cotton Growing Association were completely destroyed by root-rot fungus. Cottons sown late, i.e. in June, were liable to attack by the black-headed cricket. Several plots in Nasirabad and Kachhi were destroyed by this pest. Some damage was also done by heavy bud and boll shedding.

Cotton production

There is no regular cotton industry in North Baluchistan and therefore almost all that is produced is sold to the local *bania* who carries it to Sind.

As regards the acreage and the total produce of cotton in the areas surveyed there were no records available excepting the records kept by the British Cotton Growing Association for their own cottons in Usta. My own

estimate of the total land under cotton for 1937-38 is 3,400 acres arrived at as follows :—

	2,500	acres under the British Cotton Growing Association in Usta Colony
	550	„ round about Sibi
	200	„ in Gandawa
	50	„ in Dadhar
	100	„ in Nushki
Total	3,400	acres

Out of these 3,400 acres, about 70 acres (in Gandawa and Dadhar only) were under *herbaceums*, while the remaining 3,330 acres were under the introduced Punjab-American cottons. The total produce of *kapas* from these 3,400 acres (at an average of 200 lb. per acre) will be about 8,500 mds.

There are no ginning factories in Baluchistan and therefore the *kapas* is sent to Jacobabad, Shadadkot, Sukkur, Dharki and Reti in Sind. Bhawalpur State *kapas* also goes to these places. The British Cotton Growing Association have their own ginning factories at Reti. Cottons when grown in Jhalawan or Las Bela find their way to Dadu and Karachi respectively. There are great possibilities of growing cottons in the Kachhi Division of Kalat State, Sibi district and Nushki. Kalat State has already taken a lead in the matter and established an agricultural farm at Gandawa, where cottons from Sind are being tried. Round about Sibi, Mr Ata Mohammad, a local zamindar, has devoted a considerable part of his lands to cotton. There is a handicap due to the scarcity of water, but some improvements in water supply are already in progress. Nasirabad sub-division already enjoys the benefit of the Kirthar branch of the Sukkur Barrage and has irrigation available all the year round. In areas like Sibi, Dadhar, Gandawa and Nushki, there are a number of *karezes* and some more are being provided. The soil is alluvial and seems to be particularly well fitted for cotton wherever irrigation is available.

In Nasirabad I was informed that cultivators are lazy and do not want to work for cotton which requires more care and work than other crops. I think the trouble is due more to the reduced share they get in the *batai* (i.e. share in the produce of the crop). If they are given half of the produce as in the Punjab, instead of one-third as they are getting in Nasirabad, probably they would feel more encouraged to take to cotton. Another handicap, in my opinion, is that cultivators do not know from where to get the seed. The British Cotton Growing Association's activities are confined to Nasirabad only. In other places the difficulty can be obviated by the tehsildars or maustaufees who can easily make arrangements for the supply. A further impetus to cotton-growing can be given by awarding prizes in the local exhibitions and fairs which are frequently held.

Quality of cotton

Mekran

The single plant samples and bulks brought were examined for maximum halo-length by Bailey's protractor and for ginning percentage. For halo-length five seeds per plant and 50 seeds for each bulk were examined. The results are tabulated on the next page.

Herbaceum		Single plants					Bulks				
		Lint length in mm.			Ginning percentage		Lint length			Ginning percentage	
Locality		No. of plants	Range	Average	Range	Average	No. of Bulks	Range	Average	Range	Average
Dasht area	Meshud	20	21-28	24·1	21-34	26·6	*	*	*	*	*
	Suntsar	4	22-26	24·3	23-27	25·2	*	*	*	*	*
	Jan Mohd. Bazar	40	21-29	24·8	18-33	26·3	8	23-26	24·6	22-32	24·7
	Zareen Bagh	10	20-29	24·9	21-29	23·4	2	24-27	25·5	21-29	24·9
	Langasee	21	23-30	26·7	19-30	26·3	2	24-25	24·5	23-26	24·6
	Hasadi	9	23-27	25·5	17-40	29·5	2	26-27	26·5	22-29	25·6
	Kuddan	18	20-32	26·5	18-32	22·2	5	27-28	27·8	25-28	25·7
	Total	122	20-32	25·3	18-33	25·7	19	23-28	25·8	21-32	25·1
Kulanch area	Nokbur	69	20-30	24·7	22-42	31·3	7	24-26	25·3	26-35	29·5
	Sardasht	20	22-29	25·7	26-41	33·2	3	25-26	25·4	28-31	30·1
	Zahreen Kahur	20	21-29	24·9	21-39	31·5	4	23-25	24·6	28-39	31·6
	Total	109	20-30	24·9	21-42	31·6	14	23-26	25·0	26-39	30·4
Kech area	Nasirabad	*	*	*	*	*	1	27·7	27·7	33·2	33·2
	Tump—Pale green plants	*	*	*	*	*	1	27·5	27·5	27·9	27·9
	Tump—Dark green plants	*	*	*	*	*	1	25·0	25·0	23·5	23·5
Total for all the areas		231	20-32	25·1	18-42	28·5	36	23-28	25·9	21-39	28·3

The data for halo-length and ginning percentage were statistically examined for differences between the areas of Dasht and Kulanch, within the areas (i.e. between localities of each area), and within localities (i.e. between fields of each locality). The results obtained are the following :

(*1*) *Halo-length.*—(*a*) In halo-length, while there were no significant differences between Dasht and Kulanch areas, the localities Langasee and Kuddan were both significantly superior to Meshud and Jan Mohammad Bazar.

(*b*) In the localities Langasee and Nokbur, fields differed significantly between themselves.

(*2*) *Ginning percentage.*—(*a*) In ginning percentage, the Kulanch area was 6 per cent significantly higher to the Dasht area. As for the localities, Meshud, Jan Mohammad Bazar and Langasee were significantly superior to Kuddan in the Dasht area, and Sardasht to Nokbur in the Kulanch area.

(*b*) In Nokbur, fields differed significantly between themselves.

(*3*) The statistical examination of the halo-length of pale green and dark green *herbaceums* obtained from Tump (Kech) showed that the pale greens had 2·5 mm. significantly longer halo-length than the dark greens.

(*4*) On correlating the averages of halo-lengths and ginning percentages of single plants obtained from 18 different fields in Mekran with the averages of bulks obtained from the same fields it was found that the coefficient of correlation (r) for the halo-length was $+ 0{\cdot}4370$, and that for ginning percentage $+ 0{\cdot}7237$ both being significant at $P = 0{\cdot}01$. The lint of the *herbaceums* collected from Mekran was sent for fibre test to the Technological Laboratory, Matunga. The fibre particulars received from there are given below :

1. Mean fibre-length (inch)

(*a*) By Balls Sorter	0·78
(*b*) By Baer Sorter	0·78

2. Mean fibre-weight per inch (millionth of an ounce) 0·265

3. Maturity test results (per cent)

(*a*) Mature	79
(*b*) Half mature	12
(*c*) Immature	9

According to the report, the Mekran *herbaceums* have very nearly the same mean fibre-length and mean fibre-weight per inch as Wagad-8 cotton grown in Viramgam and have 79 per cent mature fibres as compared to 47 per cent only in the latter collected this season. It is stated that they belong to a much inferior class of *herbaceums* as compared with those collected by the author from Iran in 1936 [Ansari, 1940]. A comparison of the Mekran *herbaceums* with the above Iranian *herbaceums* and the standard Indian *herbaceums* with regard to season, soil, yield, quality, etc. can be had from the Appendix.

North Baluchistan

The halo-length and ginning percentage for the single plants are given below :

Locality	Type of cotton	Halo-length in mm.			Ginning percentage	
		No. of plants	Range	Average	Range	Average
Khari . . .	*Herbaceum* .	10	22-28	25·7	20-28	23·8
Kot Bachal Shah .	Do. .	13	21-26	24·3	22-37	25·2
From near the Seed Farm, Gandawa .	Do. .	21	19-31	24·7	16-34	26·4
		44	19-31	24·9	16-34	25·5
Nasirabad, Kachhi, Sibi and Nushki .	*Hirsutums* (P-A)	66	20-35	29·7	21-38	30·4

SUMMARY

(1) The cotton-growing areas in Indian Mekran and Kalat State of south and east Baluchistan and of Nushki in north Baluchistan were surveyed. Mekran grows *herbaceum* cottons, while in most parts of north and east Baluchistan, the indigenous *herbaceums* have been replaced recently by the Punjab-Americans introduced from Sind.

(2) Excepting the Kech Valley, where cotton is a minor crop, constituting about 10 per cent of the total production, cotton is sown all over Mekran as a mixed crop with rows of *jowar* and pulses in between. While in Kech there is a permanent source of irrigation, in other portions of Mekran, the crop depends on rain water or flood irrigation and is ratooned for even six years.

(3) A rough survey of the pests and diseases revealed that the severity of incidence did not vary from place to place. Stenosis was the only disease of importance and it amounted to about 14 per cent of the plants. Among insects observed the two bollworms, spotted and pink, were more prominent and white-fly to a smaller extent, the total insect-infected plants amounting to about 17 per cent of the population.

(4) Only a negligible amount of cotton produced in Mekran, is consumed inside the country. There are no ginning factories in Mekran. The merchants in Gawadar and Pasni buy *kapas* from the cultivators and send it to Kathiawar for ginning and sale. The Act prohibiting the import of unginned cottons into Kathiawar ports has resulted in the accumulation of two years' stocks, up to about 8,000 mds.

(5) The estimate of the yearly export of *kapas* from Indian Mekran to Kathiawar and Cutch, as reckoned from the data obtained from different sources, comes to about 10,000 mds.

(6) In North Baluchistan, the agricultural conditions of Nasirabad are more or less like those of Sind. The tract enjoys the beneficence of the Kirthar branch of the Sukkur Barrage. The *herbaceum* here, which now occupies only a very small area, was practically free from diseases and pests. In places where the American cotton has now been grown for some years the crop was found to suffer badly from bollworms and plant lice, the total incidence amounting to 20-30 per cent of the plants. There was also some damage due to root-rot fungus.

(7) About 3,400 acres are reckoned to be under cotton in north Baluchistan. All the *kapas* is sent to Sind for ginning.

The bulk of the samples examined by the Matunga Laboratory was found to have 0·78 in. mean fibre-length and 0·265 mean fibre-weight per in., both very nearly the same as of Wagad-8 grown in Viramgam, and 79 per cent mature fibres as compared to 47 per cent only in the latter collected this season.

Acknowledgements

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I am indebted to Mr K. Ramiah, M.B.E., for help in writing this paper. My thanks are also due to Dr C. Chandrasekar, Statistician, Institute of Plant Industry, Indore, for help in the statistical analysis of the data dealt with in the paper.

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APPENDIX

Comparison of Mekran (Baluchistan) Herbaceums *with Iranian and standard Indian* Herbaceums

(Data for Indian cottons are from Tech. Bull. Series A, No. 49, July 1939)

Type	District of growth	Growing period	Soil	Annual rainfall	Temperature (°F.)	Yield of *kapas* per acre	Ginning percentage	Fibre-length (in.) Balls	Fibre-length (in.) Baer	Fibre-weight per inch (millionth of an ounce)
				Mekran *herbaceums*						
Mekran (Baluchistan) *herbaceums*	Valleys of Dasht, Kech and Kulanch	Sown between February and March in Dasht and Kulanch valleys and in April or May in Kech. Picked from the end of July till October	In Dasht valley, clayey, soft and white. In Kech sandy clay and grey. In Kulanch either clayey like that of Dasht or sandy clay like that of Kech	At Pasni, the average = 0·399 inches	At Pasni, the average = 75·5 ± 42·1	150 to 400 lb. per acre	Average = 28·3 Range from 21 to 39	0·78	0·78	0·265
				Iranian *herbaceums*						
Iranian *herbaceums*	Siestan, Khorasan, Guilan and areas of Qom Kashan, Isfahan and Faras	Sown all over Iran from March to May except in South Iran, where it is earlier, the first 3 weeks of February. Picking from July to October	Predominantly light loam. The exceptions are the heavy soil areas of Tehran to Morchikhat and Isfahan	In Siestan and East Khorasan about 4 in. In Western Khorasan about 9 in. In Tehran and roundabout 5 in. In Isfahan about 5 in. and in Bushire about 13 in. The number of irrigations varies from 4 to 6 depending upon the availability of water	At Mashhad (Khorasan) mean = 56·3 and range from 15 to 76. At Tehran, mean = 60·4 and range from 30 to 111. At Isfahan mean = 58·0 and range = −3 to 106. At Shiraz mean = 65·0 and range = 21 to 113. At Bushire average = 75·4 and range = 91 to 109	400 to 600 lb.	33 per cent in East Iran, 40 per cent in Guilan area and 33 per cent in Isfahan area	0·90	0·94	0·195

Indian *herbaceums*

Jayawant	Dharwar, Belgam, Bijapur, etc.	Sown from the first week of August to the end of September and usually picked from the second week of February up to middle of April	Deep and medium black soil	20 in. to 30 in.; 27·67 in. in 1938-39	Average minimum about 60	Normally about 300 lb.	26—29	0·88; 0·89 in 1938-39	0·197 in 1938-39
Surat 1027 ALF	Broach tract .	Sown from third week of June and picked from the last week of February onwards	Black cotton soil	30 in. to 40 in.; 36·9 in. in 1938-39	Mean 85 from April to August. Mean 81 from September to November. Max. 110; Min. 55	553 lb. in 1938-1939	37·5	0·93; 0·93 in 1938-39	0·197 in 1938-39
Wagad-8 .	North Gujrat-Viramgam, N.-W. Kathiawar and Cutch	Sown in the beginning of July and picked in March	*Besar*, a saltish alluvium	13 in. to 30 in.: 14·57 in. in 1938-39	Mean 110, minimum 52, lowest monthly average =59·7 (December)	518 lb. in 1938-1939	38 in 1938-39	0·80; 0·80 in 1938-39	0·270 in 1938-39
Hagari .	Bellary district and also in parts of Raichur district in Hyderabad	Sown from the last week in August to the end of September and picked from about the first week of February to the end of March	Black cotton soil	Normally 20 in.; 22·09 in. in 1938-39	Mean minimum = 63·2, range 44·5 to 76·0, mean maximum 89·7, range 78·7 to 102·8	Normally 250 lb.; 490 in 1938-39	28	0·89; 0·90 in 1938-39	0·192 in 1938-39

THE TIME OF DIFFERENTIATION OF THE FLOWER-BUD OF THE MANGO

BY

P. K. SEN

Physiological Botanist and Officer-in-charge

AND

P. C. MALLIK

Botanical Assistant, Fruit Research Station, Sabour, Bihar

(Received for publication on 13 April 1940)

(With Plates VII and VIII)

Introduction

IN a study of alternate bearing in the mango [Sen, 1938, 1939 ; Lal Singh and Khan, 1939] it seemed important to determine the time of flower-bud formation, firstly to elucidate the factors governing their formation, and secondly to determine the time at which cultural treatments aimed at controlling flower-bud formation should be applied to give the desired effect at the critical time of bud differentiation.

In the case of deciduous fruits, such as the apple, pear, plum, cherry, etc. it has been determined that the flower-buds are formed during the summer preceding the spring in which they open. The time of flower-bud differentiation coincides with the time at which elongation growth tends to cease ; the weather is rather dry and hot and the concentration of carbohydrates in the tissue increases rapidly [Chandler, 1925]. Flower-bud formation may be inhibited or favoured by cultural treatments, such as manuring, pruning, thinning, etc. given to bear the desired effect upon shoot growth and the carbohydrate-nitrogen ratio.

The mango is evergreen and in this case shoots are found to grow in more than one flush, the earliest being about the beginning of March (under Sabour conditions). These growths usually break out of terminal buds on previous year's shoots that fail to flower. Subsequent flushes appear as laterals in April or beginning of May on previous year's shoots that flower but fail to set fruit. In July-August laterals may appear on bearing shoots after harvesting. There is often yet another flush of growths appearing still later in the year—as late as September-October. These generally arise from the weak growths of the previous year that usually fail to produce any growth, vegetative or reproductive, earlier in the season. After they have had some time to mature themselves and accumulate sufficient reserves, they may throw new growths towards the end of the season. Besides, some secondaries on current year's primary shoots are also found to appear during this period. It has been found that the early shoots that cease elongation growth about the end of June are the ones most likely to flower in the following season. Those yet growing as late as September-October seldom flower [Sen, 1939]. Generally the March shoots and some of the early laterals are most likely to flower in the following year.

Although the mango is evergreen, there occurs a complete cessation of growth for a short period from the middle of November to the middle of December. Immediately the growth is resumed the flower-buds become apparent by their swelling. It would, therefore, appear that bud differentiation must take place sometime between this time and the preceding June, i.e. the time at which the category of shoots most prone to form flower-buds tend to cease length growth. It is intended in the study described below to determine the time of flower-bud differentiation more precisely.

Material and method

Three trees of 15-year old Langra mangoes, in one of the experimental orchards (New Orchard) at Sabour, were selected for this study in 1937. The trees were in good health but had already shown the habit of alternate bearing. In 1937 and 1939 they were in their ' off ' year while in 1938 they were in their ' on ' year. The orchard received no treatment except three to four ploughings a year. March shoots were labelled during the last week of May, when they were yet easily recognizable. The shoots were selected at random all over the tree ; 200-250 shoots per tree were taken. Samples of terminal buds from the labelled shoots were collected at regular intervals from June to the following January to study their microtome sections. From June to September samples were taken every fortnight. Later on, from October to January weekly samples were collected. Each sample consisted of three or four terminal buds taken from the labelled shoots on a tree making a total of 10 buds collected from the three trees.

The work was repeated in 1938 and 1939. In these years two more trees were used for the supply of the material, as it was feared that the three trees originally selected in 1937 might be adversely affected if so many buds were removed from them year after year. In 1938 material was collected beginning from 25 July and in 1939 from 1 September. In 1938 samples were taken every fortnight from 25 July to the 16th of the following January. In 1939, it was decided to take weekly samples from 1 September till the middle of the following January.

In each case care was taken to collect buds distributed all over the trees. The buds were removed close to the base by a clear cut with a sharp knife and placed immediately in formalin-alcohol, and were then removed to the laboratory where they were evacuated under an exhaust pump (Geric). The material was then washed and dehydrated through the alcohols following the usual technique. When the buds were in 70 per cent alcohol they were cut off from the woody base and the outer hard scale leaves were removed [Gibbs and Swarbrick, 1930]. The buds were then passed through the alcohol and xylol series as usual till they reached pure xylol for clarification. They were then embedded in paraffin of melting point 48°–52°C. Radial longitudinal sections were cut and stained in Haidenhain's iron-alum hæmatoxylin.

A flowering shoot of mango is quite familiar. It consists of primary, secondary and tertiary floral branches. The rachis and the primary and secondary branches are racemes while the ultimate branches are dichasia. The

inflorescence is known as panicle. The mean size of the buds before they begin to swell in December is 1·0 cm. × 0·7 cm., whereas a normal panicle of Langra is easily about 20 cm. in length and 15 cm. spread at the bottom. During the month of January when the flower heads are very rapidly developing but yet only about 2-3 cm. in length, one easily notices the primary branches, known as panicula, emerging in the axils of the bud scales which themselves also grow in size. Between this time and the latter part of February, the panicles develop rapidly to full bloom. For the purpose of determining whether a bud is differentiating into a flower-bud or not, the earliest indication was considered to be the occurrence of rudiments of the primary floral branches in the buds. For actual microscopical examination the criterion employed was the occurrence of protrusions in the axils of the bud scales. In the first year it was advantageous to begin the microtomical work with the material collected after bud swelling in December and proceed retrogressively examining the earlier samples. The microphotographs of sections of buds in Plates VII and VIII show the phenomenon very clearly.

Results

The data for 1937, 1938 and 1939 are presented in Tables I, II and III respectively.

In the two poor bearing years of 1937 and 1939, differentiation was first definitely noticed in the beginning of October. In 1938, when the trees had borne a heavy crop, differentiation was delayed by about a fortnight, but in none of the years could any trace of bud differentiation be detected in any of the samples collected before the end of September. Although the shoots ceased growth as early as June or July, flower-bud differentiation did not take place before the month of October. It would, therefore, seem probable that the advent of cold and dry conditions bringing a sharp change in the climate in October is closely related to flower-bud differentiation of the mango.

Further, it is shown, especially in 1937 and 1939, when flower-bud formation was particularly favoured, that the number of buds differentiating into flower-buds increase steadily from the beginning of October to the middle of November. This suggests that flower-bud differentiation is active during the whole of this period, i.e. about six weeks immediately preceding the time of cessation of growth from the middle of November to the middle of December.

The short delay in the initiation of bud differentiation in 1938 would seem reasonable because this year the tree having produced a heavy crop was liable to run into exhaustion. The carbohydrate-nitrogen ratio* was probably less favourable so that although necessary seasonal change might have appeared by the end of September, the other factors did not become favourable till a few days later. In this case, as will appear from Table II, even after October, only a small percentage of the sampled buds were found to differentiate flower-buds, as compared with those in the case of 1937 and 1939. Incidentally, two extra samples were taken on the 2nd and 16th January,

* A high carbohydrate-nitrogen ratio favours flower-bud formation [Chandler, 1925]

FIG. 1

Primary floral branch primordia ($\times 40$) (first sign of flower-bud differentiation seen as small protrusion in the axil of bud-scale indicated by white arrow-head)

October 10, 1938

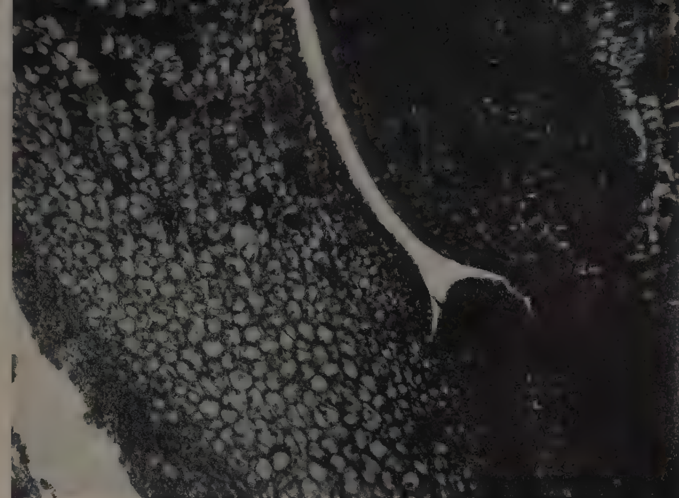

FIG. 2

Site of protrusion more highly magnified ($\times$ 180) to bring out the differentiation of the primordia seen in Fig. 1

October 10, 1938

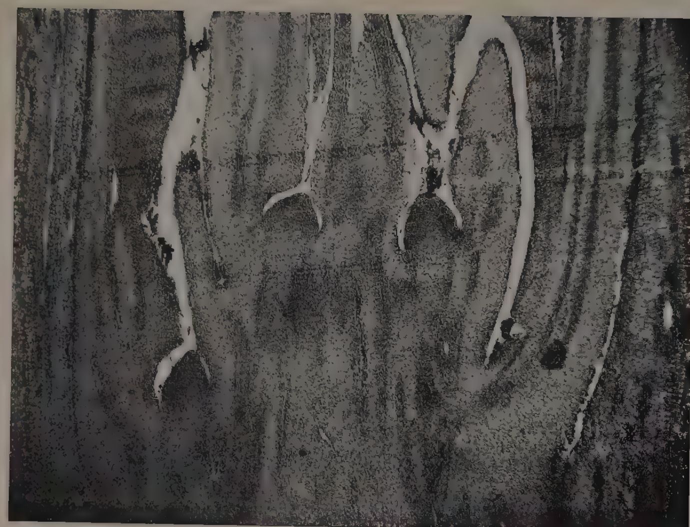

FIG. 3 Flower-bud differentiation at a more advanced stage ($\times 40$)
December 30, 1937

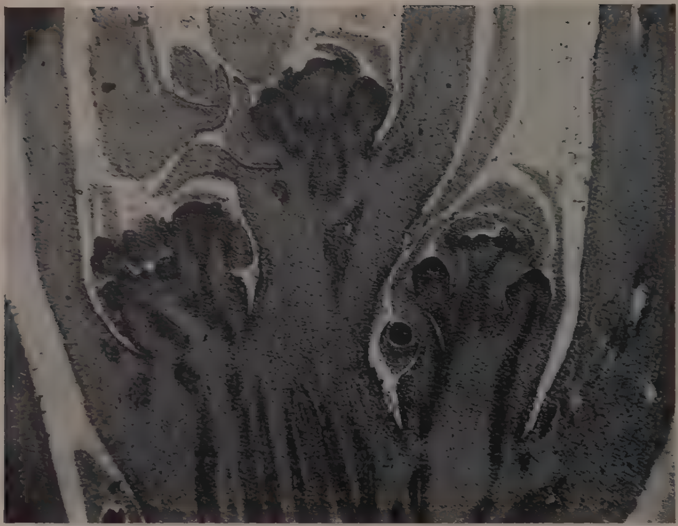

FIG. 1. Flower-bud at a still more advanced stage showing the panicula being differentiated (×40)
January 20, 1940

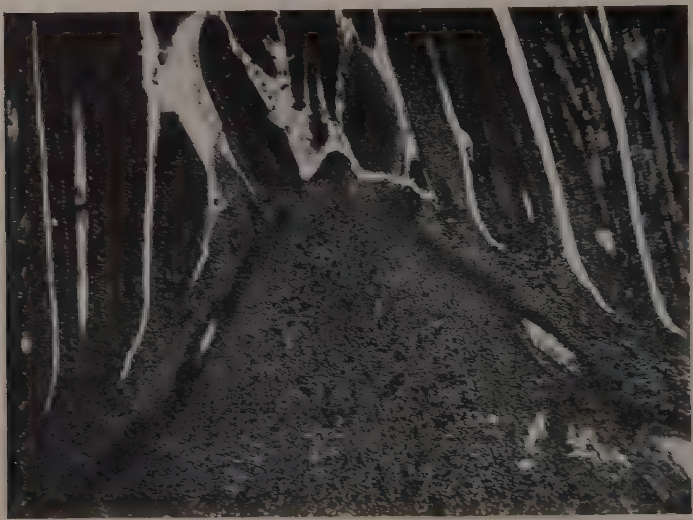

FIG. 2. Vegetative bud without any protrusion in the axils of bud scales (×40)
January 2, 1939

1939, i.e. during the season in continuation of that of 1938, consisting of buds looking relatively fatter. Only these two samples included a fairly high percentage of flower-buds, indicating that flower-buds may be fairly accurately recognized by their characteristic size even before they break.

TABLE I

Time of flower-bud differentiation in mango (Langra), 1937

Serial No.	Date	No. of buds collected	No. * of buds examined	Thickness of section in microns	No. differentiated into flower-bud
1	June 1	10	10	10	*Nil*
2	June 16	10	10	10	*Nil*
3	July 1	10	10	10	*Nil*
4	July 16	10	10	8—10	*Nil*
5	August 1	10	10	8—10	*Nil*
6	August 16	10	10	10	*Nil*
7	September 1	10	10	10—15	*Nil*
8	September 16	10	10	10—15	*Nil*
9	September 30	10	10	10—15	*Nil* †
10	October 7	10	10	10	3
11	October 14	10	10	10	4
12	October 21	10	10	10—15	6
13	October 28	15‡	12	10	5
14	November 4	10	10	10	8
15	November 11	10	10	10	9
16	November 18	10	8	10—15	7
17	November 25	10	10	25	8
18	December 2	10	10	20	8
19	December 9	10	10	20	10
20	December 16	10	10	15	9
21	December 23	10	..	..	..
22	December 30	10	10	15	9

* Some buds were spoiled during operation
† Doubtful in two cases
‡ Just by chance, 5 buds each were collected from the three trees on this date

TABLE II

Time of flower-bud differentiation in mango (Langra), 1938

Serial No.	Date	No. of buds collected	No.* of buds examined	Thickness of section in microns	No. differentiated into flower-bud
1	July 25 . .	10	10	8—10	*Nil*
2	August 8 . .	10	10	8—10	*Nil*
3	August 22 . .	10	10	8—10	*Nil*
4	September 5 .	10	10	10	*Nil*
5	September 19 .	10	10	10	*Nil*
6	September 26 .	10	8	8—10	*Nil*
7	October 10 .	10	9	15	*Nil* †
8	October 24 .	10	10	12	2
9	November 7 .	10	10	10	1
10	November 21 .	10	10	15	2
11	December 5 .	10	10	14	1
12	December 19 .	10	10	12—14	2
13	January 2, 1939	10	10	10—12	1
14	January 2, 1939 .	10 (fat buds)	10	12	8
15	January 16, 1939	10	10	10	2
16	January 16, 1939	10 (fat buds)	10	14—16	7

* Some buds were spoiled during operation
† Doubtful in two cases

TABLE III

Time of flower-bud differentiation in mango (Langra), 1939

Serial No.	Date	No. of buds collected	No. of buds examined	Thickness of section in microns	No. differentiated into flower-bud
1	September 1 .	10	10	8—10	*Nil*
2	September 8 .	10	10	10	*Nil*
3	September 15 .	10	10	12	*Nil*
4	September 22 .	10	10	8	*Nil* *
5	September 29 .	10	10	14	*Nil* *
6	October 7 . .	10	10	10—12	2
7	October 14 .	10	10	12	3
8	October 21 .	10	10	10	5
9	October 28 .	10	10	10	4
10	November 4 .	10	10	10	4
11	November 11 .	10	10	12	7
12	November 18 .	10	10	10	8
13	November 25 .	10	10	8	6
14	December 2 .	10	10	10—12	8
15	December 9 .	10	10	12	9
16	December 16 .	10	10	12—14	8
17	December 23 .	10	10	14	[illegible]
18	December 30 .	10	10	14	10
19	January 6, 1940	10	10	14	9
20	January 13, 1940	10	10	14	10

* Doubtful in one case

It is found that in the case of mango, the shoots that flower in the following year make most of the extension growth early in the season and cease growing about a month earlier as compared to the shoots that do not flower

in the following year [Singh and Khan, 1940]. Again from the data presented here, it is shown that although a shoot may cease growing as early as June-July, it does not initiate bud differentiation before October. It would, therefore, seem that in the case of the mango there must pass an interval between the time of cessation of elongation growth and that of bud differentiation. It is probable that the shoot matures and accumulates appropriate reserves during this interval.

The critical time of bud differentiation occurring immediately before the time of cessation of growth, between two years' activities, is particularly marked by the change in climatic conditions. It is likely that any shoot that ceases elongation growth early enough to allow an interval sufficient to mature itself and accumulate necessary reserves before the critical time of differentiation may form a flower-bud. As the shoots of the first flush and the relatively early ones of the subsequent flush are most likely to cease growth early enough, they are the ones most likely to flower in the following year. And it is believed that although shoots of the first (March) flush have only been used in the present study the critical time of bud differentiation determined is good for the tree as a whole for all practical purposes. It may, however, be interesting to study the shoots of the different flushes separately with a view to elucidating the subject further.

Summary and conclusion

The importance of the knowledge of the time of flower-bud initiation of the mango in the study of the problem of its alternate bearing has been pointed out.

The time has been determined using 15-year-old Langra mangoes which were in good health but had already developed alternate bearing habit.

Terminal buds on shoots of the earliest flush (March flush) which are the ones most likely to flower in the following year were collected at suitable intervals between June and the following January when the buds begin to break open. Radial longitudinal microtome sections of these buds were studied. The presence of protrusions in the axils of bud scales was used as the criterion for detecting flower-bud differentiation (Plates VII and VIII).

The study was made in the three consecutive years of 1937, 1938 and 1939. In the first and third years the trees were in their ' off ' years while in 1938 they were in their ' on ' year.

In all the three years flower-bud differentiation was first detected after the end of September. Although the shoots had ceased growth as early as June-July, no differentiation could be detected earlier.

There is an interval between the time of cessation of growth and that of bud differentiation. It is believed that the shoots mature and accumulate appropriate reserves during the interval.

In 1938 when the trees were in their ' on ' year flower-bud differentiation was first detected a fortnight later than in 1937 and 1939. This year flower-bud formation was poor.

The progressive increase in the number of differentiated buds from the beginning of October to the middle of November, especially in the 'off' years of 1937 and 1939 when flower-bud differentiation was greatly favoured, indicates the extent of the period of active differentiation.

The sharp change in climatic conditions brought about by the end of September, namely the advent of cold and dry weather, appears to be one of the determining factors for fruit-bud differentiation of the mango.

For all practical purposes the month of October and the first half of November, under Sabour conditions, i.e. a period of about five to six weeks immediately preceding the period of cessation of growth in November-December may be taken as the critical time for flower-bud differentiation. In localities where flowering occurs some time earlier or later than at Sabour, the time of flower-bud differentiation and also the period of cessation of growth would vary accordingly.

In conclusion, the authors wish to thank the Imperial Council of Agricultural Research under whose scheme the work was done. Thanks are also due to Dr H. K. Mookerji, Professor of Zoology, Calcutta University, for affording the facilities, and to Mr M. M. Chakravarty, Lecturer in the same Department, for kindly taking the microphotographs.

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INVESTIGATIONS ON THE STORAGE OF ONIONS

BY

D. V. KARMARKAR, M.Sc., Ph.D., A.I.I.Sc.

AND

B. M. JOSHI, M.Sc.

Cold Storage Research Scheme, Kirkee

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(With Plate IX and two text-figures)

I. Introduction

ONION (*Allium cepa*) is a very common cultivated crop in India. It is very widely used as a vegetable and relish by almost all classes of people in the country and, on account of its cheapness, is always in good demand. Onions can be kept for considerable periods in dry or ordinary storage, but losses due to sprouting, root-growth, fungal rots and driage under such storage conditions are often considerable. The bulbs can be preserved without loss for long periods, if kept under good ventilation and in dry air conditions. For example, onions are stored very effectively as braided bundles of bulbs harvested along with the leaves and hung on ropes or bamboos. Such a method, however, cannot be adopted on a large scale [Gokhale, 1929].

Onions come into the market in large quantities in the harvesting season, from March to May in the Bombay province, and the prices at that time almost always fall very low. It is, therefore, often advantageous to store the produce for some time so as to wait for better market rates. In the onion-growing tracts of the Bombay province, special storage houses are erected with grass-thatched roofs and with sides constructed of bamboos placed at intervals so that air can freely circulate. Even then, frequent inspection of the store, sorting out and removal of any rotting bulbs and turning over of the stored material are essential to successful storage. Otherwise, the loss by drying and rotting may come to as high a figure as 30 to 40 per cent of the total stored material. With proper ventilation and good care, this loss may be reduced to 15 to 20 per cent [Gokhale, 1929]. In lots held in ordinary storage for six months at Pusa, Walton [1928] recorded a loss of 58 per cent by weight in onions stored on racks and 46 per cent in bulbs stored in baskets. In the same experiment, the losses on account of rotting were 5·5 and 13·1 per cent of the initial weight respectively.

Cold storage has been found to be advantageous in the preservation of stored onions as, at low temperatures, the loss in weight is reduced and sprouting prevented. Rose, Wright and Whiteman [1933] found that a temperature of 32°F. with 70 to 75 per cent relative humidity was desirable for the successful storage of onions for five to six months. At higher humidities, onions were disposed to root-growth and decay. These authorities have stated that

about one-third of the onion crop of the northern onion-growing States in the U. S. A. is put into cold storage before the winter months for consumption late in the spring. Platenius, Jamison and Thompson [1934] found that onions kept in perfect condition at 30° and 32°F. for six months. At these temperatures, the relative humidity of the air was found to be of little importance and onions remained dormant and free from decay for the entire storage period in an atmospheric humidity of 95 per cent or higher. Cleaver [1934] observed that both low temperature and low atmospheric humidity were important considerations in onion storage, but of these two factors temperature was considered to be more critical. High temperature induced early sprouting—the most important cause of losses—and, as a result of his observations, he recommended that onions should be stored as near 32°F. as possible.

Wright, Lauritzen and Whiteman [1932], working with Yellow Globe onions stored at 32°, 40° and 50°F. under low, medium and high humidities, recorded that the bulbs sprouted least at the lowest temperature. Their investigations showed that the relative humidity had little influence on sprouting, but root formation, on the other hand, increased consistently with the humidity and bore little relation to temperature. The same investigators [1935] made further observations on the storage of several other varieties of onions and concluded that the amount of sprouting occurring during the storage was influenced little by humidity but definitely by temperature. The amount of decay showed only a slight tendency to increase as both temperature and relative humidity were increased, and most of the decay was identified as 'neck-rot'. They concluded that the best storage environment for onions was 32°F. with a relative humidity of about 64 per cent.

A series of experiments were carried out in connection with the cold storage of onions by Williams [1937] in Australia. It was proved that onions could be kept in good order and condition in cold storage for several months. Several packages of onions of the two varieties, Brown Spanish and Silver Skin, were placed in cold storage at various temperatures ranging from 25° to 35°F. and the best results were obtained from a temperature of 32°F. with a humidity of 87 per cent. Heiss [1937] carried out investigations on the gas-storage of onions and the results of his experimental work indicated the very definite superiority of nitrogen gas storage over ordinary cold storage.

In India, considerable losses are experienced annually in the storage of onions, but no work has yet been carried out on improvement in the methods of storage at the different producing centres. Storage investigations on onions were started in 1937 under the Cold Storage Research Scheme, Ganeshkhind Fruit Experiment Station, Kirkee, financed by the Imperial Council of Agricultural Research, and the results so far obtained are reported in this paper.

II. Temperature of storage

There are two common varieties of onions cultivated in the Bombay province, the White and the Red. Preliminary storage trials in 1937 with

both these varieties showed that the onions sprouted more quickly at 52°F. than at higher or lower temperatures. At 52°F. the bulbs commenced sprouting after six weeks. At 32°F. they remained without sprouting for more than six months, while at a temperature maintained between 75° and 85°F. only a few of the bulbs had sprouted at the end of a year. However, most of the onions kept at such a high temperature of storage got dried up considerably after eight months of storage. Further experiments were made with onions of the Red variety only as they are more readily available in the Poona market.

Sprouting and root growth

The influence of the temperature of storage on the rate of sprouting and root growth was determined in 1938. A hundred onions, selected for uniform size and stage of maturity, were kept in trays at each of the temperatures, 32°, 35°, 40°, 48°, 52°, 60°, 68°, 75°-85°, 90°-95°F., and at room temperature (laboratory room), which varied considerably during the period of the experiment. The temperatures of 75°-85°F. and 90°-95°F. were maintained in cabinets by the use of electric lamps. The relative humidity in the chambers at the temperatures of 32° to 68°F. was generally between 80 and 90 per cent. At 75°-85°F. and at 90°-95°F. humidity was not controlled in any way but varied according to the outside atmospheric conditions.

The onions were examined every fortnight when the number of onions which showed sprouting or root growth was recorded. The resultant data are given in Table I. It will be observed that onions stored at 48°, 50° and 60°F. sprouted earlier than those kept at higher or lower temperatures. The range of temperatures between 48° and 60°F. appeared to be more conducive to the sprouting of onions, 60°F. being the optimum temperature in this respect. This range of temperatures is reached at many places in Northern India during winter and this may be, perhaps, the reason why most of the onions obtainable in the ordinary markets during the cold weather months are sprouted and shrivelled in appearance. At 32°F. the onions remained dormant for six months but commenced sprouting in the seventh month. At 75°-85°F., sprouting was negligible and at 90°-95°F. there was practically no sprouting, only two bulbs (which had rotted) showing the development of weak sprouts after eight months of storage. At room temperature, there was no sprouting as long as the minimum atmospheric temperature was high (70°F.) but sprouting commenced as soon as it decreased below 60°F. in the winter months.

There was no root growth at 75°-85°F. or at 90°-95°F., but at the lower temperatures new roots were produced. The difference in the periods required for new roots to appear at the different lower temperatures indicated that such root formation was related to temperature, the relative humidity being equal at all these temperatures. It was also observed that sprouting was not in any way connected with root formation as many bulbs sprouted without the appearance of new roots. That a high humidity is necessary for root formation was seen from the observation that a few bulbs kept at

TABLE I

*Rate of sprouting and root formation of onions at different temperatures**

Storage period in months	32°F.		35°F.		40°F.		48°F.		52°F.		60°F.		68°F.		75°-85°F.		90°-95°F.		Room temperature		
																			Mini-mum		
	S.	R.	S.	R.	S.	R.	S.	R.	S.	R.	S.	R.	S.	R.	S.	R.	S.	R.	(°F.)	S.	R.
1 (June-July)	0	0	0	0	0	0	0	100	3	98	4	0	0	0	0	0	0	0	70	0	0
2	0		0	49	2	98	28	...	22	...	60	91	12	39	0	0	0	0	70	0	0
[illegible]	0	65	1	95	32	...	75	...	51	...	83	...	24	68	1	0	0	0	70	0	1
[illegible]	0	87	12	...	66	...	89	...	73	...	93	...	35	82	1	0	0	0	72	0	5
5	0	...	53	...	92	...	95	...	79	...	99	...	40	...	3	0	0	0	58	6	...
[illegible]	6	...	89	...	99	...	100	...	87	...	100	...	55	...	4	0	0	0	50	16	...
7	31	...	97	...	100	...	...	...	93	...	...	...	72	...	5	0	0	0	46	36	...
[illegible]	57	...	...	...	...	...	...	...	94	...	...	...	84	...	6	0	1	0	52	44	...
[illegible]	89	...	...	...	...	...	...	...	100	...	...	...	...	...	...	0	2	0	51	50	...
10	100	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	2	...	52	...	...

* S represents the percentage of sprouting and R the rate of root formation

52°F. in a desiccator, with calcium chloride as the drying agent, did not show root growth. In another experiment, the bottom end of the bulbs was covered with melted paraffin wax in order to prevent the effect of moisture on root development in the storage atmosphere. In this experiment, no growth of new roots was visible at the root-end of the onions. On opening the bulbs, however, it was observed that root growth had taken place, but was underneath the outer red scale and extended towards the neck-end of the bulbs.

Fungal rotting

In the storage experiments described above rotting was not observed to any appreciable extent at any of the storage temperatures tested. Fungal growth appeared on the tips of new roots formed in storage but was limited to the roots only and did not attack the bulbs. The temperature of 75°-85°F. is not much above the atmospheric temperature in the rainy season at Poona and hence the relative humidity in the storage cabinet was approximately equal to the atmospheric humidity. The onions stored at 75°-85°F. became damp during the monsoon months and gradually showed the appearance of a black mould on the outer scale. At 90°-95°F., a temperature higher than the normal atmospheric temperature, the onions remained dry and rustled when handled. There was no wastage for the first eight months of storage at 90°-95°F. On prolonged storage at this temperature, however, some of the less mature onions became dried up and developed black mould or were attacked by small insects (thrips). A few of the bulbs also showed soft rot.

Effect of temperature of storage on the subsequent rate of sprouting

For this experiment, onions were stored at 32° and at 90°-95°F. Two samples, each consisting of 25 bulbs, were taken from each of these temperatures after 1, 3, 5 and 7 months of storage respectively and kept at 52° and at 68°F. The rate of sprouting after removal to these temperatures was determined. The resultant data are given in Table II. It was observed that storage at 32° or at 90°-95°F. hastened the rate of sprouting which also increased with the length of the storage period. The rate of sprouting of onions stored at 32°F. was higher at 68° than at 52°F. More than half of the onions stored for five months at 32°F. sprouted at 68°F. within three days after removal from the low temperature, and within a week at 52°F. The onions stored at 90°-95°F. for five and seven months remained without sprouting at 68°F. for ten and seven days respectively. These observations indicated that onions stored at 32°F. for more than three months should be consumed soon after removal from cold storage, whereas the onions stored at the high temperature of 90°-95°F. did not sprout until at least a week after removal to atmospheric temperatures of between 50° and 70°F., this period being available therefore for the distribution to consumers. The sprouting capacity of onions was not impaired in storage either at 32° or at 90°-95°F. as almost all the bulbs subsequently sprouted satisfactorily when removed

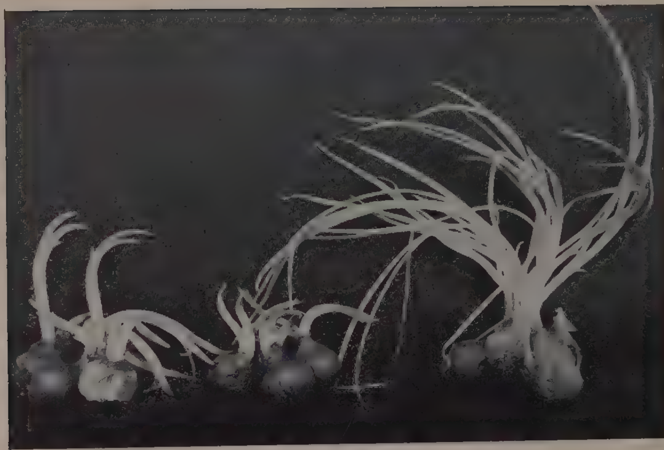

FIG. 1. Sprouting of onions at 52° and 68° F. after removal from the storage temperatures of 32° and 90°-95° F.

A B

FIG. 2. Fully mature (A) and immature (B) onions

to temperatures of 52° and 68°F. (Plate IX, fig. 1). The sprouts from onions stored at 90°-95°F. appeared to be sturdier than from those stored at 32°F.

Relation of the size of onions to the rate of sprouting under storage conditions

One hundred onions of large size (average weight 120 gm.) and of small size (average weight 60 gm.) were kept at 52°F. and the rate of sprouting was determined. It can be seen from the results given in Table III that the large onions sprouted more quickly than the small ones. Similar results were also obtained at 32°F. after six months of storage when the bulbs commenced sprouting.

TABLE II

Effect of the storage temperature on the subsequent rate of sprouting after removal to 52° and 68°F.

Number of days after removal	Percentage of sprouted onions							
	At 52°F. Period of storage in months				At 68°F. Period of storage in months			
	1	3	5	7	1	3	5	7
Stored at 32°F.								
3	0	0	4	48	0	0	56	64
7	0	0	68	80	0	8	88	88
10	0	12	88	92	0	36	92	88
14	0	28	96	92	0	44	92	92
22	12	40	100	..	4	52	96	..
Stored at 90°-95°F.								
3	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	12
10	0	0	4	48	0	0	0	44
14	0	0	20	56	0	0	12	52
22	0	0	68	88	0	12	48	68

TABLE III

Rate of sprouting of large and small onions at 52°F.

Storage period in weeks	Percentge of sprouted onions	
	Large	Small
2 . .	0	0
4 . .	2	0
6 . .	18	5
8 . .	57	28
10 . .	72	55

III. Loss in weight of onions in storage

Relation of the size of the bulbs to the rate of loss in weight

In 1937, onions of two sizes, large (average weight 120 gm.) and small (average weight 60 gm.) were kept at 30°, 40°, 52° and 68°F. and the loss in weight in storage was determined. The results are given in Table IV, from which it can be seen that the percentage loss in weight of the small onions was higher than that of the large ones at all the four temperatures of storage under experiment.

Table IV

Rate of loss in weight in storage of large and small onions

Number of days of storage	Percentage loss in weight							
	30°F.		40°F.		52°F.		68°F.	
	Large	Small	Large	Small	Large	Small	Large	Small
6	0·85	0·85	0·75	1·23	0·86	1·26	1·63	1·90
15	1·71	1·97	1·44	2·55	1·91	2·36	2·90	3·22
22	2·49	2·82	2·06	3·17	2·97	3·71	3·75	4·46
30	3·02	3·51	2·44	3·96	3·57	4·33	4·18	4·74
38	3·48	4·28	2·94	4·76	4·43	5·05	4·67	5·60
46	3·94	4·88	3·44	5·64	5·15	5·91	5·24	6·26
54	4·53	5·74	4·07	6·04	5·81	6·54	5·52	6·74

Influence of the storage temperature on the rate of loss in weight of onions

The relative loss in weight of onions at different storage temperatures ranging from 32° to 90°-95°F. was determined. Fully developed onions of uniform size (each weighing about 70 gm.) were selected and a sample was kept at each of the temperatures used. Each sample consisted of 20 bulbs which were kept in a small tray. The samples were weighed every month and the loss in weight was determined. The results obtained are given in Table V.

Table V

Relative loss in weight of onions at different temperatures

Period of storage in months	Percentage loss in weight							
	32°F.	35°F.	40°F.	48°F.	52°F.	68°F.	75°-85°F.	90°-95°F.
1	1·07	1·60	2·32	3·25	3·24	2·84	3·00	5·06
2	2·28	3·49	5·51	*7·56	*7·69	*5·67	5·85	8·43
3	3·71	5·65	*9·49	11·59	12·29	9·03	8·21	11·43
4	5·77	*8 29	13·41	15·19	17·40	12·23	10·92	14·87
5	7·77	11·36	17·68	18·80	..	15·43	14·63	18·09
6	10·20	15·05	22·10	..	..	19·69	20·20	21·13
7	*12·33	18·67	26·01	..	..	25·02	26·20	26·29
8	14·40	22·58	..	..	..	..	33·48	31·37
9	16·90	..	..	..	..	..	39·48	38·32
10	..	..	..	..	..	..	..	43·71

* Sprouting commenced

The values of the percentage loss in weight at 32°F. and 90°-95°F. have been represented graphically in Fig. 1. It can be observed that there was a steady increase in the rate of loss in weight of the samples stored at 32°F. In the early stages of storage, the loss in weight of samples stored at 90°-95°F. was much higher than of those at 32°F., but after six months of storage, when the onions stored at 32°F. commenced sprouting, the loss of weight in the bulbs kept at 90°-95°F. was only roughly double that of those kept at 32°F. The rate of loss in weight during storage at 90°-95°F. remained constant for the first six months. There was then an increase and this change in the rate occurred when the loss in weight had reached more than 20 per cent of the original weight and the outer scale was completely dried up. It was found that the outer scale of an onion of the size used in this experiment formed about 20 per cent of the total weight of the bulb. When the outer scale became dried up, transpiration commenced to take place directly from the next inner scale. There was then a change in the rate of loss in weight, possibly because transpiration occurred from a fresh scale and also because the volume of the bulbs decreased with an increase in the surface-bulk ratio.

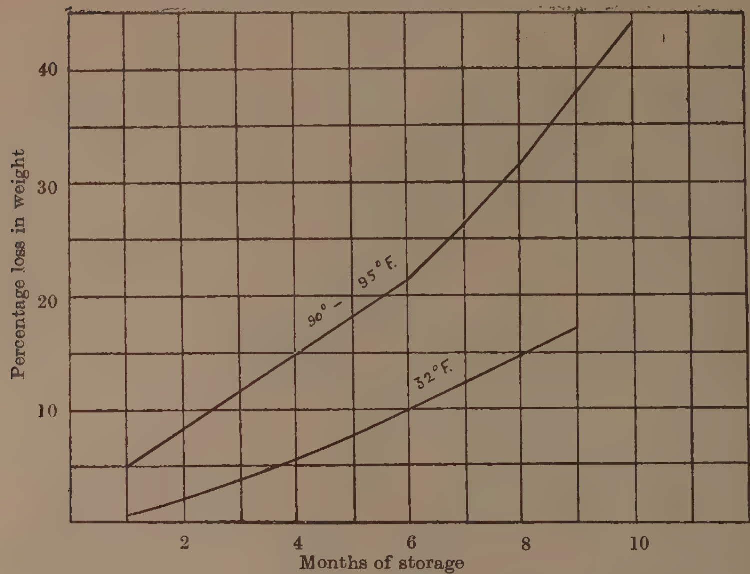

FIG. 1. Rates of loss in weight of onions stored at 32° and 90°-95°F.

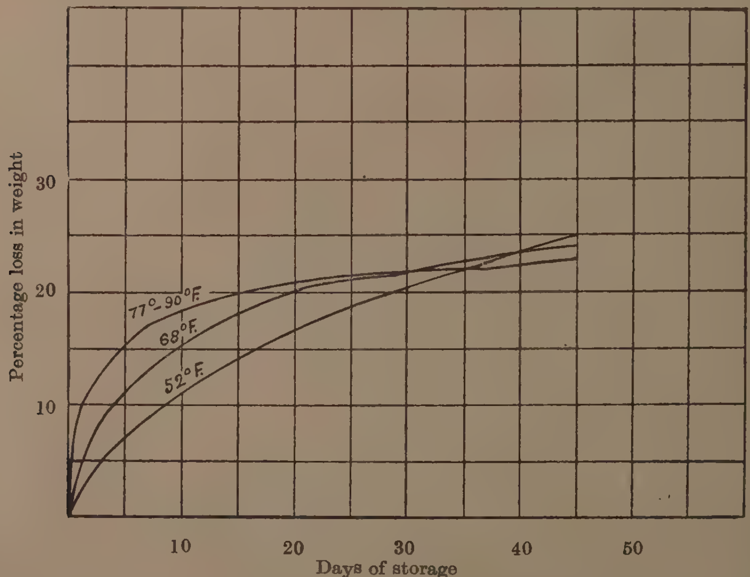

FIG. 2. Rates of loss in weight of 'young' onions stored at 52°, 68° and 77°-90°F.

In 'young' onions, the rate of loss in weight was very rapid in the beginning of storage at 52°, 68° and 77°-90°F. until the outer scale was dried up

and the thin red coat or membrane was formed. This occurred when the loss in weight was about 20 per cent of the initial weight. After this the rate of loss in weight considerably slowed down (Fig. 2). The red coat appeared to serve as a good protection against transpiration. To minimize loss in weight, therefore, it would appear to be necessary that sufficient care is taken in handling onions in storage so that the red coat is not damaged or removed but remains intact.

The experiments described above to determine the loss in weight of onions stored at different temperatures were made by using only a few bulbs in each sample. In another experiment, the loss in weight in storage was determined with bigger samples. About 80 lb. of onions were packed in trays and kept at 32° and also at 90°-95°F. The results obtained showed that with larger quantities also the loss in weight at 90°-95°F. was nearly double the loss at 32°F.

Influence of the stage of maturity of the onions on the loss in weight

In the 1938 storage trials at temperatures of 32° and at 90°-95°F., it was observed that the stage of maturity or development of the onions was not so important a factor in loss of weight at the former as at the latter temperature. At 90°-95°F. onions which were immature, *i.e.* harvested before the leaves were completely dried up in the field and the bulbs were not fully ' capped over ' and which were of ' thick neck ', rapidly lost water and became desiccated. In one sample consisting of 20 immature bulbs weighing 1,400 gm. at the time of placing in storage at 90°-95°F., the weight of the sample at the end of 10 months of storage was only 58 gm.

In 1939, two lots of onions, one of bulbs fully mature or completely ' capped over ' (Plate IX, fig. 2A) and the other of bulbs ' just mature ' but of thicker neck (Plate IX, fig. 2B), were stored at 90°-95°F. and the loss in weight was determined. The weight of each sample was about 80 lb. and the onions were packed in trays. The results given in Table VI show that the loss in

TABLE VI

Relative loss in weight of fully mature and ' just mature ' onions at 90°-95°F.

Period of storage in months	Percentage loss in weight	
	Fully mature	Just mature
1	2·12	4·17
2	4·25	7·68
3	7·30	9·84
4	11·10	14·52
5	13·68	19·36
6	18·84	25·87
7	24·92	32·06
8	32·06	41·41

weight of the 'just mature' onions was greater than that of the fully mature ones. Woodman and Barnell [1937] have demonstrated that the loss in weight takes place mainly by evaporation of water from the inner surface of the scales and therefore mainly through the neck. The higher loss in weight from 'just mature' onions might therefore be due to the thicker neck of the bulbs, permitting increased evaporation of moisture from the interior.

IV. Chemical changes in onions at different storage temperatures

The pungency of onions remained unaffected in storage either at the low temperature of 32° or at the high temperature 90°-95°F.

Changes in the amount of water, total nitrogen, reducing, non-reducing and total sugars in onions during sprouting and during storage at 32° and 90°-95°F. were determined. Ten bulbs were used for each sample. The outer red scale and the inner whorl of scales containing the dormant green shoots or buds were removed and the remaining portion of the bulb was cut into small pieces. The methods described by Cheema, Karmarkar and Joshi [1939] were used for the analyses. The results are given in Table VII.

Table VII

Changes in the chemical composition of onions during sprouting and in storage at 32° and 90°-95°F.

Stage of maturity	Percentage of water	Percentage of total nitrogen	Percentage of reducing sugars	Percentage of non-reducing sugars	Percentage of total sugars
			During sprouting		
Dormant (fresh)	87·9	0·120	2·97	5·67	8·64
Just sprouting	87·2	0·150	3·86	4·78	8·64
Sprouts one inch long	88·3	0·150	3·60	4·71	8·31
Sprouts two to three inches long	87·2	0·129	3·55	4·42	7·97
			Stored at 32°F.		
Storage period in months					
5	87·4	0·136	5·17	4·05	9·22
7	87·3	0·128	5·10	4·00	9·10
			Stored at 90°-95°F.		
5	87·2	0·184	2·27	5·60	7·87
7	86·5	0·208	1·64	6·66	8·30
9	87·4	0·210	1·59	6·06	7·65
11	85·3	0·250	1·55	5·90	7·45

These results show that, during sprouting, there were no marked changes in the chemical composition of the pulp, except that there was an increase in the percentage of total nitrogen and that the percentage of reducing sugars rose slightly. In onions stored at 32°F., there was a very marked increase in the amount of reducing sugars and also an increase in the amount of total sugars. In onions stored at 90°-95°F., the amount of reducing sugars decreased considerably, showing an increase in the amount of non-reducing sugars as the percentage of total sugars remained unaffected. At this high temperature of storage the percentage of total nitrogen steadily increased, indicating that there was a transfer of nitrogen from the inner whorl of scales containing the green shoots.

V. Rate of respiration of onions in storage

The rate of respiration of onions during storage at 52° and 32°F. was determined. The results are given in Table VIII, from which it can be seen that the rate of respiration increased during storage. At 52°F., there was a sudden increase, the value becoming double the original value after 10 days of storage. At 32°F., the increase may be due to the increase in the amount of reducing sugars. The rate of respiration has been expressed in terms of c.c. of carbon dioxide at 68°F. produced per 100 gm. per 24 hours.

Table VIII

Rate of respiration of onions during storage at 52° and at 32°F.

52°F.		32°F.	
Number of days of storage	Rate of respiration	Period of storage in months	Rate of respiration
0 . . .	4·1	0	2·0
10 . . .	8·0	1	2·9
24 . . .	8·8	2	3·2
38 . . .	10·3	3	3·5
52 (started sprouting)	11·2	4	4·0
		5	4·0

VI. Summary

1. The results of the investigations carried out from 1937 relating to the storage of onions (*Allium cepa*) have been described.

2. Onions sprouted more quickly at storage temperatures from 48° to 60°F. than at higher or lower temperatures. At 32°F., they remained dormant in storage for six months, while at the high storage temperature of 90°-95°F. they did not sprout at all. The storage at 32° and 90°-95°F. increased the rate of subsequent sprouting when the bulbs were removed to temperatures of 52° or 68°F. At these temperatures, the onions removed from previous storage at 32°F. sprouted earlier than those from 90°-95°F. Thus more than

50 per cent of the onions stored at 32°F. for five months sprouted within three days after removal to a temperature of 68°F., while onions stored at 90°-95°F. for an equal period remained at 68°F. without sprouting for 10 days. New roots were produced in storage at 32°F., but at 90°-95°F. there was no root formation. The size of the bulbs appears to influence the rate of sprouting as, in storage at 52°F., large bulbs sprouted at a faster rate than small ones. There was no rotting during the first eight months of storage at 90°-95°F.

3. Small onions lost weight more rapidly in storage than large ones. The percentage loss in weight of onions stored at 90°-95°F. for six months (21 per cent) was roughly double the loss on storage for a similar period of time at 32°F. The stage of maturity of the stored onions greatly influenced the loss in weight in storage at 90°-95°F., onions which were fully developed or completely 'capped over' at the time of harvesting losing the least in weight.

4. The pungency of the onions remained unaffected in storage either at 32° or at 90°-95°F. There were no marked changes in the chemical composition of onions during sprouting. In storage at 32°F. there was a very marked increase in the amount of reducing sugars and also an increase in the amount of total sugars. In storage at 90°-95°F. the percentage of total sugars in the bulbs did not alter, but the percentage of reducing sugars decreased, thus increasing the proportion of non-reducing sugars.

5. The rate of respiration increased during storage. At 52°F. there was a sudden increase after storage commenced. At 32°F., the increase in the respiration rate during storage may be due to the increased concentration of reducing sugars.

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*A NEW MICRO-IODINE METHOD FOR THE DETERMINATION OF STARCH IN PLANT MATERIAL

BY

J. J. CHINOY

Punjab Agricultural College, Lyallpur

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It has been shown elsewhere [Chinoy, Edwards and Nanji, 1934] that under certain standard conditions the amount of iodine present in the iodide-complex is constant, and that if these conditions are observed, it is possible to determine starch accurately and rapidly. Conditions were standardized for the precipitation of starch iodide and weighing it as such. This gravimetric starch-iodide method has already been successfully used for determining soluble starch, pure commercial starches, as well as starch in flours, potato tubers and various leaf materials [Chinoy, Edwards and Nanji, 1934 ; Chinoy, 1938].

The success of all these methods for the accurate determination of starch in plant material depends largely upon its complete extraction.

During the investigations of the cotton failure problem [Dastur, 1939] it was found by microscopic examinations of the leaves that starch accumulation occurred in leaves of 4F American cotton plants that produced badly opened bolls. A necessity, therefore, arose to devise a suitable method for determining starch quantitatively in order to support the microscopic observations. It was, therefore, attempted to develop a micro-technique on the lines already described [Chinoy, 1938] for the determination of starch in leaves, roots, stem and reproductive parts of the cotton plant. Under the standardized conditions outlined below it is possible to work with only 0·1 to 0·3 gm. of plant material instead of 1-5 gm. generally taken in the current methods [Chinoy, 1938 ; Widdowson, 1931]. It has an advantage as extraction is facilitated and a larger number of analyses can be carried out in the same amount of time.

Experimental

Soluble starch and pure commercial starches

In the first instance experiments were carried out with pure soluble starch and wheat and rice starches in order to determine the recovery on a microscale. Aliquots of 5 ml. from standard starch solutions were pipetted out in clean test-tubes and starch was determined. The results are given in Table I.

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*This work was done in the Punjab Physiological (Cotton Failure) Scheme financed by the Indian Central Cotton Committee.

TABLE I

Recovery of starches

Calculated		Found	
Starch analysed	Starch (dry weight) per cent	Starch iodide in 5 ml. aliquot (mg.)	Starch (dry wt.) per cent
Soluble	0·2796	1·598	0·2818
,,	0·2796	1·577	0·2796
Rice	0·5412	2·957	0·5242
,,	0·5412	2·993	0·5306
,,	0·5412	2·945	0·5221
,,	0·5412	2·923	0·5182
,,	0·5412	2·952	0·5234
,,	0·5412	2·957	0·5242
Wheat	0·5930	3·290	0·5833
,,	0·5930	3·315	0·5877
,,	0·5930	3·301	0·5851
,,	0·5930	3·364	0·5966

The results show that micro-filter tubes are suited for the gravimetric determination of starch iodide on a micro-scale.

Extraction of starch from plant material

Suitable aliquot parts (0·1 to 0·3 gm.) from the dry powder are weighed accurately and placed in specially prepared centrifuge tubes. These centrifuge tubes were made in the laboratory. About 0·5 gm. of fine, purified sand and approximately 1 ml. of 0·7 per cent KOH solution are added to each tube and the plant material is crushed for about five minutes against the bottom of the tube with a glass rod. The mixture is made into a paste by the addition of another 9 ml. of the KOH solution. The tubes are placed in a boiling water-bath for one hour. After about one hour's heating the tubes are removed from the bath and centrifuged. Four extractions are usually sufficient to remove all the starch. After the centrifuging and the decantation of the fourth extract about 5 ml. of water are added and the material is shaken and centrifuged. In case the blue colour persists in the washing a fifth extraction is made.

Determination of starch

For the determination of starch the general procedure for neutralization of the alkali, addition of iodine and precipitation of starch iodide by addition of potassium acetate is the same as described previously [Chinoy, 1938]. It is, however, necessary to reproduce here in detail the micro-technique used for precipitation and filtration.

The requisite amount of the solution (1 to 5 ml. or more), as ascertained by the preliminary test, is pipetted into a centrifuge tube and neutralized with the necessary quantity of 10 per cent acetic acid, and 0·5 ml. of 0·1 *N*

iodine solution (which must be in excess) and 2 ml. of 10 per cent potassium acetate solution are added. The precipitate thus obtained is kept overnight (if necessary) for proper coagulation.*

The solution together with the precipitate is centriguged. About 10 ml. of 30 per cent alcohol are added to the precipitate, and, after thorough mixing, filteration and washing of the starch iodide precipitate is carried out as follows in a micro-filter tube originally used by Pregl [1937].

The whole of the precipitate and liquid are siphoned into a tared micro-filter tube[1] by applying gentle suction. The sides of the centrifuge tube are then washed with about 3 ml. of 50 per cent alcohol and the liquid is sucked in. This operation is repeated twice with 3-4 ml. of 95 per cent alcohol. The siphon is now disconnected and the precipitate is washed twice with 95 per cent alcohol by filling the filter tube each time.

Finally absolute alcohol is aspirated once through the tube. The filter tube is dried in the oven at 70°C. for one hour and weighed. The weight of the starch is obtained by multiplying the weight of starch iodide by the factor 0·8865.

Determination of starch in plant material

The above micro-method was used for the determination of starch in a study of the carbohydrate accumulations in leaves, stems, roots, buds and bolls of the 4F Punjab-American cotton. Detailed account of this investigation will be given elsewhere. It is intended to present here some select data indicating the accuracy and efficiency of the above method.

TABLE II

Plant material	Sample analysed (gm.)	Aliquot taken (ml.)	Starch iodide found in aliquot part (mg.)	Starch (dry weight) per cent
4F cotton root . . .	0·1136	10	1·958	7·64
,, ,, ,, . . .	0·2130	5	1·818	7·57
,, ,, ,, . . .	0·0645	10	1·171	8·22
4F cotton stem . . .	0·3960	5	4·306	9·64
,, ,, ,, . . .	0·1560	10	3·631	10·27
,, ,, ,, . . .	0·4210	10	9·834	10·36
4F cotton leaf . . .	1·0850	10	10·781	4·40
,, ,, ,, . . .	0·8200	10	8·044	4·35
,, ,, ,, . . .	0·5976	3	1·744	4·31

* In the case of the cotton plant the necessary coagulation was obtained within two hours.

[1] Asbestos is previously cleaned by repeated treatments with sulphuric-chromic acid and hot nitric acid and then washed with distilled water till free from acid. It is then suspended in distilled water ready for use.

TABLE II—*contd.*

Plant material	Sample analysed (gm.)	Aliquot taken (ml.)	Starch iodide found in aliquot part (mg.)	Starch (dry weight) per cent
4F cotton flowers and buds (I)	0·6608	10	4·412	2·96
" " " . .	0·6608	10	4·353	2·92
4F cotton flowers and buds (II)	0·7870	10	6·879	3·87
" " " . .	0·7870	10	6·837	3·85
4F Bolls : mature carpels (I) .	0·5118	5	3·122	5·41
" " " (I) .	0·2535	10	3·267	5·71
" " " (I) .	0·2535	10	3·289	5·75
4F Bolls: young green carpels (II) . . .	0·7224	3	7·153	14·63
" " " (II) .	0·1208	10	4·107	15·07
" " " (II) .	0·1208	10	4·126	15·14

DISCUSSION OF THE RESULTS

It will be noted that the starch content in the duplicates of the same extract agree very closely. Differences observed in the figures for separate extractions are of the order of 5-7 per cent. These differences are more pronounced in the case of stem and root. The microscopical examination of the root and stem powder reveals characteristic differences in the size and shape of the particles from those of leaf, flowers and buds, and carpel, even though all of them are passed through a 100-mesh sieve. Root and stem powders contain many more elongated fibrous particles in comparison to the powders obtained from leaf, flowers and buds, and carpel. This probably accounts for the greater discrepancy in the starch contents of separate extractions of root and stem samples. It is interesting to observe that even though the amount of the sample analysed varies considerably in some cases, it does not affect the accuracy of the determination appreciably.

The recovery of pure starch as well as the effect of the presence of pectin have already been noted for the macro-method [Chinoy, 1938]. The starch iodide method has already been compared with hydrolytic method of Widdowson [1931] and found to give usually much more consistent, though slightly lower, results than the Taka-diastase method. The starch iodide method is also found to compare well with the colorimetric method described elsewhere [Chinoy, 1939].

The present method is accurate and rapid as the extraction and estimations of 12 samples can be carried out at a time in a much shorter period than that taken by any hydrolytic method for the determination of starch.

The filtration, washing and drying of the starch iodide precipitate can also be accomplished in much less time than is the case in macro-methods. It is found that the micro-filter tube (used by Pregl for halogen determination) can be successfully used for the determination of minute quantities of starch in plant material.

Acknowledgement

I wish to express my thanks to Professor R. H. Dastur for valuable suggestions and criticism.

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STUDIES ON THE PHYSICO-CHEMICAL PROPERTIES OF ASSOCIATED BLACK AND RED SOILS OF NYASALAND PROTECTORATE, BRITISH CENTRAL AFRICA

BY

S. P. RAYCHAUDHURI

Agricultural Chemistry Section, Dacca University

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(With two text-figures)

THE NATURE OF TROPICAL BLACK SOILS AND THEIR CONTRASTING PROPERTIES WITH CLOSELY OCCURRING RED SOILS

THE tropical black soils have been divided into several varieties, e.g. black turf, black vlei soils, etc., but the differences amongst the several varieties are not at all well defined. The black soils of southern India are known as ' regurs ' and are in many respects analogous to the black turfs. Shantz and Marbut [1923] regard all these tropical black soils as being analogous to the tshernosem group of the temperate climates, but Marchand [1924] is of opinion that all tropical black soils are not of the same class. Theron and Niekerk [1934], however, think that ' the black turfs are undoubtedly soils belonging to the same family as Russian chernozems '. Dealing with some aspects of the black cotton soils of the Central Provinces, India, Bal [1935] points out that the occurrence of lime concretions is a common feature in the black cotton soils, but their exact position in soil profiles depends on the depth of the soil. The notable difference between the black turf and the vlei turf is that the C-layer of the latter is frequently mottled with blue, white, and green patches, indicating a low state of oxidation through periodic waterlogging. The clay contents of these tropical black soils vary from 40 per cent to 60 per cent, and the soils generally occur only in the sub-humid and semi-arid parts of the tropics under a rainfall of about 25 to 35 in. per annum.

Kenchington [1935] has made an interesting suggestion for differentiating two great groups of pedocalic soils. On either side of the equatorial humid zone there are practically rainless deserts. To the north of this belt, which is the zone of transition to the humic temperate regions, lies the classical ' tshernosem '. To the south in the zone of equatorial humid climate lies a class of pedocalic soils to which Kenchington assigns the name *teen-suda* which is a colloquial Arabic term commonly used by the Sudanese, meaning ' clay-black '. He thinks that the regur or black cotton soil of India and the so-called vlei soils of Africa are of the class of *teen-suda*.

Regarding the cause of the colour of black soil there are two main views expressed in the literature of the subject : (*i*) some peculiar state of combination of iron, and (*ii*) a peculiar type of humification in base-saturated soils due to the presence of limestone.

(*i*) Dealing with the black cotton soil or the ' regur ' of India, Annett [1910] thinks that ' the black colour of these soils is mainly due to 1-2 per cent of soluble humus '. He recognized that ' the mineral matter alone would not account for the deep black colour '. Harrison and Ramaswami Sivan [1912] could not find titaniferous magnetite to any significant extent in the black soils from the Bellary, Kurnool and Tinnevelly districts of India, and Maufe [1928] also was unable to show the presence of this titanium compound in the black soils of Salisbury in Southern Rhodesia. Harrison and Ramaswami Sivan hold that two classes of substances are responsible for conferring the colour and physical properties to the black cotton soils of India : ' One is probably a colloidal hydrated double iron and aluminium silicate, which is mainly concerned with the formation of compound particles and which possesses, in a modified form, the properties of ordinary clay. The other is organic in character and may possibly be an organic compound [Harrison and Ramaswami Sivan, 1912]. Dealing with the cause of the black colour of the black vlei soils at Salisbury in Southern Rhodesia, Maufe [1928] comes to the conclusion that ' the colour of the black vlei soils must be due to some peculiar, but undetermined, state of combination of the iron '.

(*ii*) The view that the black colour of the black turfs is due to a peculiar type of humification in the presence of limestone was suggested by Vipond [Marchand, 1924] as early as 1912. In a recent publication Theron and Niekerk [1934] have studied this question thoroughly, and from an analysis of their results they concluded that the black colour of the soil is a direct result of the mode of weathering in respect of both the organic and mineral constituent. This view has been supported by Van der Merwe [1935].

In a recent paper, Basu and Sirur [1938] have dealt with the survey and classification of the black soils occurring in the canal zone of the Bombay-Deccan. From an examination of a large number of profiles distributed over fairly representative parts of the Nira right bank and Pravara canals, eight soil types have been traced. These authors have put forward the suggestion that the ' colour of the soils seems to be more related with moisture relationships of soils than with the actual amounts of organic matter present. Fundamentally black-coloured soils are usually found on low-lying situations, where the soils remain moist over a considerable part of the year when compared with soils on a high level where the colour is usually brown. This brown colour also indicates some breaking down of the clay complex, due to high temperatures and extreme desiccation in the summer ' [Basu, 1939].

The nature of tropical red soils has been discussed by Raychaudhuri [1937].* Quite often, in the tropics, the black and red soils are found to occur side by side under apparently the same climatic and geological conditions, and the mode of formation of these soil types has been a debated problem. Marchand [1924] has discussed at length the question of the occurrence of dissimilar soils associated with similar rocks in South Africa. He points out that the texture of a soil ' will depend on the relative proportions of kaolin, silicic acid and ferric hydroxide, and these proportions are not necessarily the same for all rocks of similar mineralogical make-up '. The presence

* Reference may also be made to the definition of laterite soil by Sen [1939].

of iron compounds in the rock makes the resulting soil more open and easily drained. Moreover, sometimes an admixture of sandy material, perhaps from an adjacent quartzite or sandstone takes place, and the resulting soil is a red heavy loam.

Viswa Nath [1939] points out that in many places in Central and Southern India black and red soils occur together in the same district. Thus he points out that granites and gneisses give rise to black soil in some places and to red soil at other places. Where the soil is red, it is usually close to the hills and overlies a thin layer of decomposed granite and highly kaolinized felspar. With increase in the distance from the hills, black soil of increasing thickness occurs, and this is found overlying a thicker layer of decomposed and kaolinized material. This is suggestive of the conversion of red soil into black soil, but as Viswa Nath rightly points out, no direct experimental proof is yet available. The data presented by Viswa Nath show that black and red soils are differentiated by their base-exchange capacities, the black soils possessing much higher base-exchange capacities than the red.

The various considerations set forth above indicate that although the general characteristics of contrasted types of tropical red and black soils are more or less well known, their actual nature is still a debated problem. Much work remains to be done in this direction, and simultaneous morphological observations in the field and physico-chemical examination of profile samples in the laboratory are desirable.*

Results with associated red and black soils of Nyasaland Protectorate, British Central Africa

At Rothamsted Experimental Station, at the kind suggestion of Dr E. M. Crowther, the author had occasion to work with two contrasted soil profiles, red and black, occurring in close localities from Domira Bay† in the Nyasaland Protectorate. Soil samples‡ of these profiles were obtained up to 6 ft. depth in 9-in. cubic blocks. Table I shows the chemical composition of the clay fractions of some of the soil samples.

It will be seen from Table I that the clay fractions of both the black and red profiles have SiO_2/Al_2O_3 ratios greater than 2, and hence these soils should not be called laterite and lateritic in the sense of the definition of Martin and Doyne [1927]. It will also be noticed that in the case of both the profiles the SiO_2/Al_2O_3 ratio increases as the depth increases. The mineralogical studies of the soils which were kindly done by Dr Nagelschmidt at Rothamsted show

* Reference may be made in this connection to the symposium on the black and red soils of Southern India, 1939, *Bulletin No. 2, Indian Society of Soil Science.*

† Domira Bay is a port of anchorage on the west coast of Lake Nyasa. The shorelands consist of recent alluvium. The average annual rainfall at Domira Bay is about 33 in. in summer. The rainfall is distributed from October to April, being heaviest towards the end of December and throughout January. Baobab trees are very common in Domira Bay soils. Columnar cracking is very marked in the black soils. The natives of Domira Bay do not like open black land, because they find it difficult to work by primitive methods. But it has been found that after two years of cotton, the black soils acquire friable structure and become easier to work.

‡ These profile samples were very kindly supplied by Mr H. C. Ducker.

that the heavy minerals of the fine sand fractions of both the black and red soils contain relatively more basic minerals, e.g. hornblende garnets, iron hydroxide, etc. This suggests that the parent materials of both soil types are basic in nature which fact might explain the gradual increase of SiO_2/Al_2O_3 ratio with increase in the depth of the soil profiles.

TABLE I

Chemical composition of clay fractions

Colour of soil profile	Depth (in.)	Per cent loss on ignition on oven-dry basis	Molecular ratios		
			$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Al_2O_3+Fe_2O_3}$	$\frac{Fe_2O_3}{Al_2O_3}$
Black	9—18	14·01	2·38	1·76	0·354
	27—36	12·83	2·38	1·77	0·343
	45—54	12·85	2·50	1·87	0·339
	63—72	12·03	2·75	2·02	0·359
Red	9—18	12·54	2·29	1·70	0·346
	27—36	12·82	2·25	1·70	0·322
	45—54	12·69	2·30	1·74	0·317
	63—72	12·49	2·44	1·84	0·328

If we consider equivalent layers of the black and red profiles, the clay fraction from the black soil appears to possess slightly higher ratios of silica/alumina and of silica/sesquioxide than the red soil. The difference, however, is not large. The average silica/sesquioxide ratio of the black and red clay fractions from Domira Bay soils is about 1·8.

Table II gives the data on the determination of the percentages of free silica, free alumina and free iron oxide in the clay fractions obtained from equivalent layers of the black and red soils. The method devised by Truog and Drosdoff [1935] was employed in the determination of these constituents.

TABLE II

Treatment of Domira Bay clays by Truog's method for dissolving free oxides of silica, aluminium and iron

Colour of soil-profile	Depth (in.)	Percentages of constituents dissolved by Truog's method		
		SiO_2	Al_2O_3	Fe_2O_3
Black . .	9—18	0·45	0·31	10·35
	63—72	0·20	0·66	7·95
Red . .	9—18	0·13	1·68	12·45
	63—72	0·13	2·16	10·82

The results in Table II show that by Truog's treatment more iron oxide is dissolved out from the red clay fraction than from the black. Also, the red clay fraction contains more free alumina than the black.* On the other hand, the black clay fraction contains more free silica than the red.

Determination of total organic carbon and of total nitrogen in the soils

Organic carbon in the soils was determined by following the rapid titration procedure devised by Walkley [1935] and total nitrogen was determined by Kjeldahl's method. The results are shown in Table III.

TABLE III

Percentages of total organic carbon and of total nitrogen

Colour of soil profile	Depth (in.)	C (per cent)	N (per cent)	C/N
Black . .	0—9	2·45	0·160	15·3
	9—18	1·13	0·092	12·3
	18—27	0·78	0·058	13·4
	27—36	0·65	0·046	14·1
	36—45	0·56	0·041	13·7
	45—54	0·38	0·029	13·1
	54—63	0·27	0·024	11·3
	63—72	0·18	0·021	8·6
Red . .	0—9	1·74	0·130	13·4
	9—18	0·79	0·078	10·1
	18—27	0·66	0·060	11·0
	27—36	0·54	0·058	9·3
	36—45	0·39	0·049	8·0
	45—54	0·31	0·043	7·2
	54—63	0·26	0·037	7·0
	63—72	0·23	0·035	6·6

It will be seen that the percentage of organic carbon decreases gradually with the depth of the soil layer. If we consider equivalent layers of the two profiles it will be noticed that the black profile contains a little more organic carbon than the red. It is, however, not likely that the black colour of black soils is due to this small excess of carbon, since it was observed that even after treatment with H_2O_2 or after continued leaching of the soils with a strong solution (10 per cent) of sodium carbonate for several days, the relative differences in the colours of the soils did not change to any appreciable extent. Also, if we consider equivalent layers of the two profiles the C/N ratios are higher for the black soils than for the red.

* In a recent paper Raychaudhuri and Sulaiman [1940] have compared the percentages of free sesquioxides in Indian lateritic and red soils obtained by the methods of Hardy [1931] and of Drosdoff and Truog [1935]. Hardy's method yields higher values for percentages of free alumina but lower values of free iron oxide.

Mechanical analysis

Mechanical analyses of the soil samples show that there is no regular variation of the clay contents with the depth of the profile. The curves in Fig. 1 show that at the topmost layers the red soil contains much less clay than the black soil, whilst very low down (from a depth of approximately 55 in. downwards), the red soil contains much more clay than the black. At intermediate layers the clay contents of the two soils are very much the same. This characteristic depth distribution of the clay fractions in the soil types may be explained as being due to a greater degree of eluviation of clay in the red soil profile which indicates a better drainage condition of this soil type.

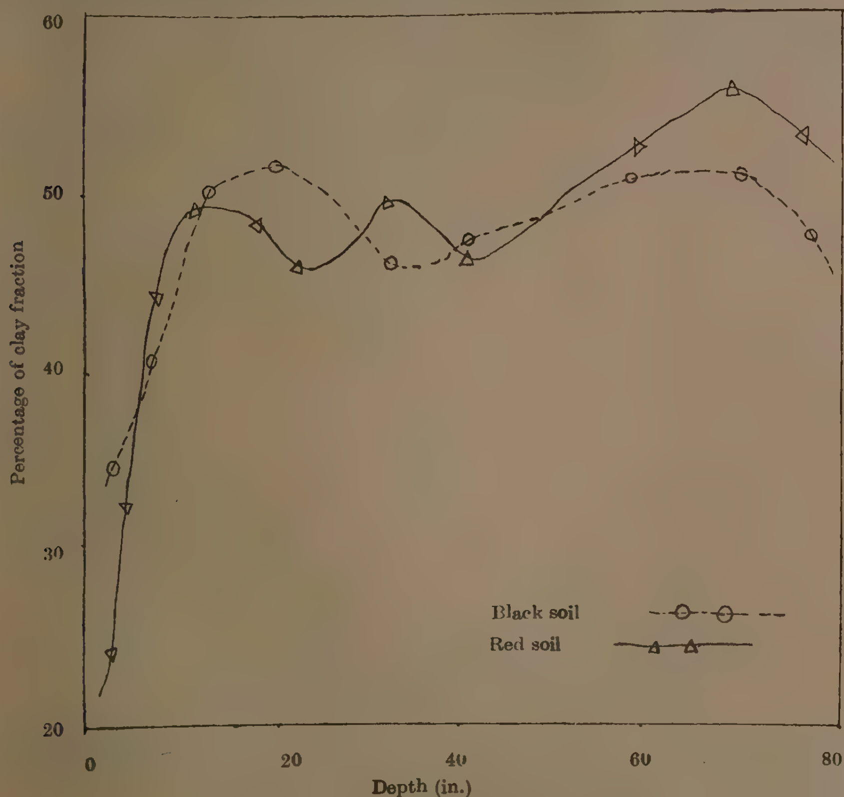

FIG. 1. Clay content of black and red soils

Examination of the buffer curves of the soil types

Fig. 2 illustrates the nature of buffer curves of two typical black and red soils obtained from equivalent depths (0 in.-9 in.) of the two profiles. The buffer curves were drawn following the procedure devised by Schofield [1933]

and used by Raychaudhuri and Nandy Mazumdar with Indian red soils [1939, 1940]. The abscissa denotes the milli-equivalents of base taken up per 100 gm. of the soil material whilst the ordinate denotes the *p*H values at which the uptakes have taken place. It will be noticed that the curve for the black soil is flatter than that for the red, indicating that the black soil possesses greater buffer action. The probable explanation of the great buffering capacity of the black soil may be attributed to higher organic matter content as well as to the presence of higher amounts of free silica in the black soil. For an examination of the nature of organic matter in the soil profiles, a comparison was made of the properties of H_2O_2-treated soils with those of original soils. The results are shown in Table IV. The method for the determination of moisture equivalent was essentially the same as described by Keen and Raczkowski [1921]. The exact procedure followed was that described by Russell and Gupta [1934].

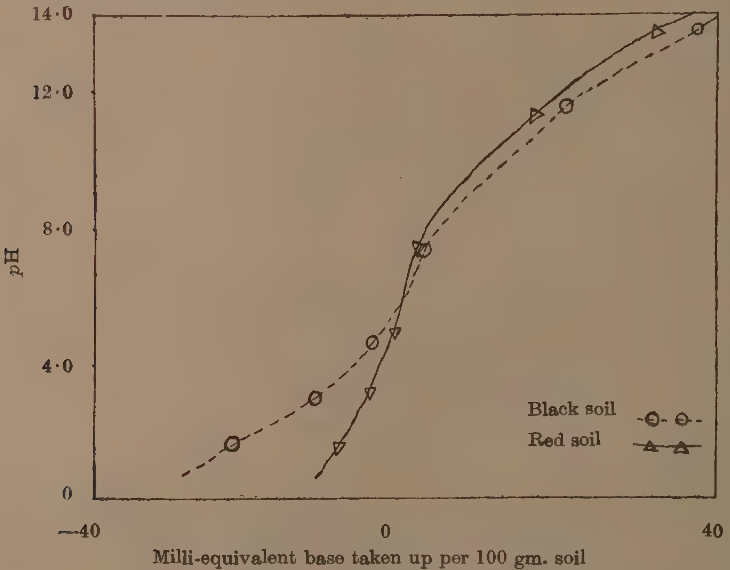

Fig. 2. Buffer curves of black and red soils

Table IV shows that with soils from top layers the moisture equivalents and the imbibitional moisture capacities decrease definitely after treatment with H_2O_2, obviously due to the removal of organic matters. At lower layers the moisture equivalents and the imbibitional moisture capacities are very much the same before and after treatment with H_2O_2. On comparing the behaviour of the black and red profiles we find that, in general, the black soil possesses higher values of moisture equivalent and imbibitional moisture capacities than the red soil, even after the soils have been treated with hydrogen peroxide. This is also remarkable, since the clay contents of the soil

types are nearly the same and the chemical composition of the black and red clays are almost identical (Fig. 1 and Table I). The data on *p*H values, on exchangeable bases and on degrees of base-saturation of equivalent layers of the profile samples are shown in Table V.

TABLE IV

Moisture equivalent and imbibitional moisture capacities

Colour of soil profile	Depth (in.)	Original soil		H_2O_2-treated soil	
		Moisture equivalent	Imbibitional moisture capacity	Moisture equivalent	Imbibitional moisture capacity
Black	0—9	24·2	11·8	20·8	10·2
	9—18	26·1	12·7	25·7	10·6
	18—27	26·1	11·8	25·8	10·9
	27—36	26·7	13·4	25·0	12·5
	36—45	26·9	13·1	26·8	11·4
	45—54	27·0	14·3	27·5	14·3
	54—63	28·2	14·8	29·2	14·9
	63—72	31·3	17·4	30·1	16·3
Red	0—9	18·9	8·0	14·8	7·3
	9—18	23·9	10·5	20·9	8·0
	18—27	21·4	7·8	21·4	8·6
	27—36	24·0	8·8	20·7	9·1
	36—45	24·7	9·4	23·6	7·6
	45—54	25·3	10·9	26·2	9·8
	54—63	28·3	12·6	26·1	9·9
	63—72	30·6	14·5	31·2	12·7

Table V shows that the black soils are base-saturated to a greater extent than the red ones. The data in this table also show that the black soil contains nearly twice the quantity of exchangeable bases as compared to red soils.

TABLE V

pH, exchangeable bases and percentages base saturation

Colour of soil profile	Depth (in.)	pH*	M. eq. of total exchange-able bases present in soils, corrected for carbonate content†	M. eq. of base taken up by 100 gm. of soil‡	Per cent base-saturation $\frac{X}{Y} \times 100$
Black	9—18	6·0	13·9	23·1	60
	27—36	6·2	13·3	21·1	62
	45—54	7·0	14·3	22·4	64
	63—72	7·2	16·0	14·0	114
Red	9—18	5·2	7·0	13·7	51
	27—36	5·8	8·5	14·1	60
	45—54	6·2	8·0	13·5	59
	63—72	6·2	9·3	17·0	55

* Determined by Kuhn's barium sulphate method

† Determined by Rice William's method [1929]

‡ Determined by Schofield's method [1933]

SUMMARY AND CONCLUSIONS

1. A review of the existing literature dealing with the contrasted nature of tropical black and red soils has been made.

2. Physico-chemical properties of two contrasted soil profiles, red and black, occurring in close localities in Domira Bay in the Nyasaland Protectorate, have been compared.

3. Clay fractions from the red and black soils have approximately the same SiO_2/Al_2O_3 and $SiO_2/(Al_2O_3+Fe_2O_3)$ ratios. If, however, we consider soil samples from equivalent layers of the profile the red clay seems to possess a somewhat lower ratio than the black.

4. Red clay fractions contain more free iron oxide and free alumina than the black, as given by Truog's treatment. Also the black clay fraction contains more free silica than the red.

5. The percentage of organic carbon of the black soil of Domira Bay was somewhat higher than that of the equivalent layer of red, but not enough to

cause the enormous difference in colour of the two soil types. The C/N ratios of the black soils were uniformly higher than those for the red, suggesting that the proportion of protein matter was higher in the red soil than in the black. The organic matter of the black soil appeared to be more readily oxidizable than that of the red.

6. The buffer curves of black soils are more flattened than those of the red, indicating that the former are more active.

7. The black soils have higher moisture equivalents and higher imbibitional moisture capacities than the red soils, although the two soil types have nearly the same clay contents.

8. The black soils are base-saturated to a greater extent than the red ones. The data also show that the black soil contains nearly twice the quantity of exchangeable bases as compared to red soils.

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STUDIES ON THE PARASITISM OF *COLLETOTRICHUM INDICUM* DAST. *

BY

T. S. RAMAKRISHNAN, M.A.

Agricultural Research Institute, Coimbatore

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(With four text-figures)

A SEEDLING blight and boll-rot of *Gossypium herbaceum* (Uppam) has been observed at the Central Agricultural Station, Coimbatore, since 1925 [Sundararaman, 1926-1931]. The disease is confined to that species alone and is influenced to a large extent by seasonal conditions. In 1930 a survey of the cotton tracts of the Madras province showed that the disease is prevalent in Sivakasi (Ramnad district) also. Dastur [1934] has recorded a similar disease from the Central Provinces, which he describes as ' anthracnose ' occurring on *Gossypium arboreum* (types Verum, Roseum and Bani) and has named the parasite *Colletotrichum indicum*. The term 'anthracnose' has been used earlier in cotton pathological literature to denote another disease which resembles this to some extent but is caused by a different fungus. Such being the case, it may be advisable to give a different name to this disease in order to remove misconceptions. For instance in the *Review of Applied Mycology* [1937 ; 1939] while reviewing Dastur's administration report it is stated that ' anthracnose (*Glomerella gossypii*) caused severe infection of cotton '. The parasite referred to by Dastur is different from *Glomerella gossypii*. The mistake is presumably due to the use of the term anthracnose for the disease in India.

During the course of studies on different species of *Colletotrichum* occurring in South India it was considered desirable to obtain a culture of *C. indicum* from Mr Dastur for purposes of comparison. Since no culture was available with him he kindly sent diseased bolls and the fungus was brought into pure culture from these. Attention was first directed to find out the parasitism of this strain under local conditions and with this end in view several infection experiments were carried out and the results are recorded in this paper.

Materials and methods

The seeds of the varieties and species of cotton used in these experiments were kindly supplied by the Cotton Specialist, Coimbatore. These were sown in pots after delinting with concentrated sulphuric acid, except where otherwise stated. The pots containing seedlings were kept after inoculation inside glazed cages with a layer of moist sand at the bottom. The cages were kept humid by spraying with water once a day. The plants were inoculated by placing bits of fungus culture at the collar region or by spraying a suspension of spores by an atomizer on the cotyledons. The bolls were inoculated after

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surface-sterilization with 0·1 per cent mercuric chloride solution and kept inside moist chambers.

INFECTION EXPERIMENTS

The first set of infection experiments was conducted on eight days' old seedlings of *Gossypium herbaceum* (H_1) and *G. arboreum* (K_1). In both the species all the inoculated seedlings succumbed. Brown lesions with water-soaked margins were formed at the collar region on the inoculated side. Later, these regions exhibited shrinkage of the tissues and the seedlings fell over. By this time the entire collar region had become blackish brown. Water-soaked spots, which later turned brown, developed on the cotyledons also. In the course of a week the seedlings had rotted down, cotyledons and hypocotyl included. On the surface of hypocotyl and cotyledons acervuli of the fungus had formed. The controls were quite healthy.

Dastur [1934] mentions that seedlings with a woody stem have not always been successfully inoculated except through wounds and that even this was not successful with plants having a well-developed woody stem. To find out the age up to which successful inoculation was possible, 20 seedlings each of the two species of cotton of varying ages were inoculated at the collar and the results are recorded in Table I.

TABLE I

Results of inoculation of seedlings of varying ages

Age of seedlings (days)	Inoculated		Control	
	H_1	K_1	H_1	K_1
4	All infected	All infected	All healthy	All healthy
8	,,	,,	,,	,,
12	,,	,,	,,	,,
16	,,	,,	,,	,,
21	,,	,,	,,	,,
27	All healthy	All healthy	,,	,,
32	,,	,,	,,	,,

Three weeks' old seedlings are readily infected. K_1 seedlings 35 days' old were inoculated after wounding the collar. There was brown discolouration of the collar but excepting for a surface crack the plants grew up healthy. Thus seedlings are liable to be infected only up to four weeks and if they escape infection for a month they are not affected by seedling blight.

The anthracnose of cotton in America has been known to be carried from year to year by the presence of the mycelium inside the seed-coat. Edgerton has noted spores of *Glomerella gossypii* on cotton seeds which were apparently healthy. Barre has shown that spores and hypahe of the same fungus remain on stalks and bolls in the field for over a year [Brown, 1938]. Both Sundararaman and Dastur have shown that in the Indian disease also the seeds may carry infection in the lint or seed-coat. Inoculation experiments were started to find out whether infection by *Colletotrichum indicum* can take place

by spores carried on the surface of the seeds and through soil as with the anthracnose in America.

Healthy (fuzzy) seeds of *G. herbaceum* (H_1) were divided into two lots of 100 each. One lot was placed in a beaker containing a spore suspension and the other in a beaker of distilled water. They were separately kept under an air pump for 10 minutes after which they were sown in pots containing sterilized soil. In the inoculated series only 14 germinated and all these succumbed in the course of 10 days, while in the control pots 62 seeds germinated and all remained healthy.

The experiment was repeated using delinted seeds instead of fuzzy ones. In the inoculated set 32 per cent germination took place, while in the control there was 75 per cent germination. All the seedlings in the inoculated series were killed in six days while the controls were all healthy.

Various types of infection could be noticed in these experiments. In most of the seeds that had not germinated (in the inoculated series) the testa had burst at the micropylar end, but there was no further progress, the embryo having turned brown. Acervuli had formed on the testa and embryo. In some the radicle had pushed out, but the seedlings were affected before the hypocotyl had come above ground or the cotyledons had freed from the seed-coat. In others the cotyledons had unfolded but had brown spots which extended and finally involved the entire seedling. In still others the cotyledons were free, but the collar was infected and the seedlings died. Thus the experiments bring out the fact that the disease can be transmitted through spores on the surface of the seed and two phases in the expression of infection —the pre-emergence phase and the post-emergence phase—are evident.

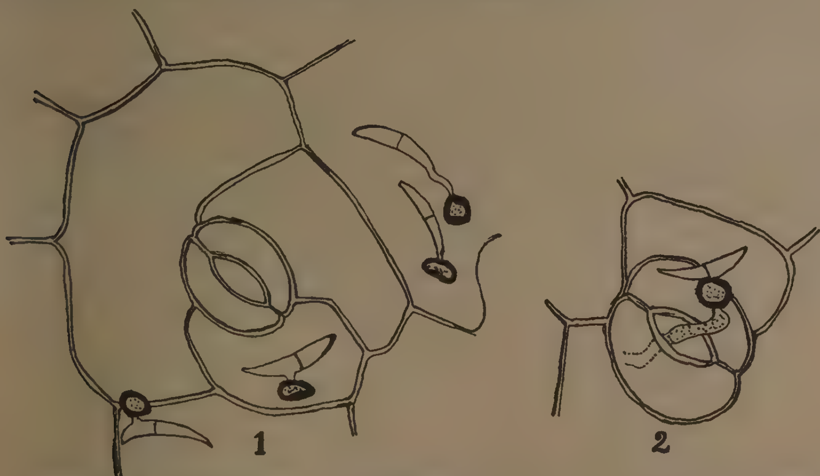
For soil infection experiments, 20 pots were filled with garden soil and autoclaved for two hours at 120°C. The soil in 10 of the pots was mixed with culture of the fungus grown on sand and corn-meal medium, while in the other 10 pots sterile medium was added. Delinted seeds of H_1 cotton were sown in all the pots at the rate of 10 seeds for each pot. In the course of a week 68 per cent germinated in the infected pots, while there was 96 per cent germination in the control pots ; but all the seedlings in the former succumbed to the disease, while all remained free from disease in the latter. This clearly shows that infection can take place from the soil also.

In another series the soil was mixed well with diseased seedlings and a fortnight later seeds were sown. In the control, healthy seedlings were cut up and mixed with the soil. All the seedlings in the former pots died in 10 days, while those in the control pots were healthy, showing thereby that the presence of diseased material in the soil is a source of danger.

Entrance of the fungus into the host

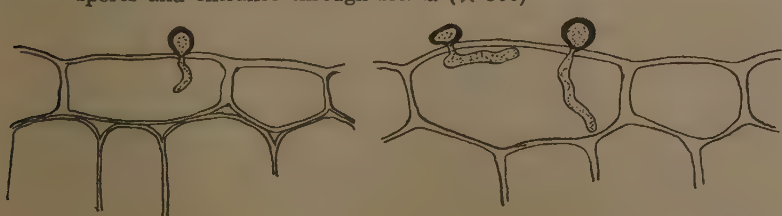
The method of penetration by the fungus into the host plant was investigated. Seedlings were infected by placing suspensions of spores on cotyledons and collar region and then covered with bell-jar for 36 hours, after which the bell-jar was removed. Sections (hand and microtome) were taken at intervals to observe the entry and spread of the fungus in the tissues. On the cotyledons discolouration was noticed at the inoculated spot in 18 hours

and well-defined brown spots appeared in 40 hours. In four days the spots had become quite brown and increased in size. After 18 hours small pieces of the epidermal tissue of the cotyledon were mounted in lactophenol and chloral hydrate (as described by Riker and Riker [1936]). It was found that the spores had germinated, a septum had formed in the middle of each spore, and appressoria had been produced either from the end of the germ tube or at the tip or side of the spore itself (Fig. 1). In a few, germ tubes had grown out of the appressoria and entered through the stomata (Fig. 2). In many others though appressoria were near the stomata there was no sign of penetration through them. Sections showed a shrinkage of the epidermal cells and from certain appressoria penetration hyphae had pierced through the outer epidermal wall and entered the epidermal cell (Figs. 3 and 4). After 42 hours inter-cellular hyphae were noticed in the mesophyll region, the cells were shrunk and some of the palisade cells had turned yellowish brown. In still later stages the hyphae were intra-cellular also, the cells had very much shrunk and lost the green colour.



1 2

FIGS. 1, 2. Surface view of epidermis of cotyledon showing germination of spores and entrance through stoma (× 500)



3 4

FIGS. 3, 4. Section of portion of cotyledon showing penetration through epidermis (× 500)

Sections of the hypocotyl taken after 18 hours showed that the epidermal cells had shrunk and turned brown and numerous appressoria had formed on the surface. After 42 hours shrinkage and discolouration had extended to two layers of sub-epidermal cells. Intra-cellular hyphae were not in evidence at this stage. Longitudinal sections revealed that in 18 hours spores had germinated, appressoria formed and penetration of the epidermal cells had taken place. In 42 hours the hyphae had developed inter-cellularly to a depth of two to three layers of cells, but they had extended more in length. In four days penetration had progressed throughout the cortex and intra-cellular hyphae were also formed. By this time the cells had shrunk and turned brown. Evidence is lacking to show that the cells are killed in advance of the mycelium. The quicker longitudinal spread of the mycelium must be responsible for the rapid extension of the lesions in length.

Varietal susceptibility

The Coimbatore isolates of *Colletotrichum* in 1925-30 had a restricted parasitism, being confined to *G. herbaceum* (Uppam). Dastur [1934] has recorded the parasitism of the Nagpur strain on G. *arboreum* (Roseum, Verum and Bani). To find out whether other species and varieties of cotton and other host plants of *Colletotrichum* species are susceptible, infection experiments with the Nagpur isolate were carried out on several indigenous and exotic types of cotton besides plants recorded as hosts for *Colletotrichum* spp. The seedlings were eight to ten days' old and at least 30 seedlings were infected in each case, except in *G. stocksii*, *G. Davidsonii*, *G. Armourianum* and *G. Harknessii* where owing to scarcity of seeds only five plants were inoculated. The results of the experiments are given in Table II.

Table II

Infection experiments with the Nagpur isolate on cotton and other host plants of Colletotrichum

Host plant 1	Part inoculated 2	Results 3
Gossypium herbaceum types—		
1 H_1	Seedling (collar)	All seedlings killed
2 H2919	"	"
3 Dharwar 1	"	"
4 Kumpta wilt-resistant	"	"
5 Jayawant	"	"
G. arboreum types—		
1 K_1	"	"
2 Sanguineum	"	"
3 Bani 306	"	"
4 Cocanadas 171	"	"
5 N 14	"	"
6 Roseum	"	"
7 Poonam	"	"
8 Tellapathi	"	"
9 Parbhani 710	"	"

TABLE II—*contd.*

Host plant 1	Part inoculated 2	Results 3
10 Verum 434 . . .	Seedling (collar) . .	All seedlings killed
11 Nadam	,, . .	,,
12 Burma C 19 . . .	,, . .	,,
G. hirsutum types—		
1 Co 2	,, . .	All healthy. No infection
2 Bourbon . . .	,, . .	,,
3 Moco	,, . .	,,
G. Stocksii	,, . .	The collar affected, lesions formed but seedlings got over the attack
G. Davidsonii . . .	,, . .	All healthy. No infection
G. barbadense types—		
1 Sea Island . . .	,, . .	,,
2 Quebra	,, . .	,,
3 Verdao	,, . .	,,
G. Armourianum . . .	,, . .	,,
G. Harknessii . . .	,, . .	,,
G. arboreum × *G. barbadense* (back-crossed with *barbadense*)	,, . .	6 seedlings out of 28 took infection and died. Others remained healthy
Hibiscus esculentus . . .	,, . .	No infection
Allium cepa (young plants) .	,, . .	,,
Brassica oleracea var. *capitata* .	Leaves and collar of seedlings	,,
,, var. *caulorapa*	,, ,,	,,
Capsicum annuum . . .	,, ,,	,,
	Green fruits (unwounded)	,,
	,, (wounded)	Fruits rotted, acervuli formed on pericarp
Aristolochia bracteata . .	Leaves. . . .	Spots developed on the leaves
Zingiber officinale . . .	Leaves (unwounded) .	No infection
	,, (wounded)	Small brown spots round the inoculated portion. No extension

Suitable controls were kept in all cases and these remained healthy throughout.

It can be seen from Table II that the Nagpur isolate is capable of infecting several of the indigenous types of cotton in the seedling stage. In *G. Stocksii* which is a wild indigenous type the spread of infection is slow and actual death of seedlings is not noticed as in other cultivated types. The exotic types which include both wild and cultivated American cottons are not infected. The hybrid between the Asiatic and Amercian cottons shows about 22 per cent infection.

Dastur [1934] has found that bolls of *G. arboreum* (Verum, Bani and Roseum) are liable to be affected by this fungus, while Sundararaman has observed boll-rot of *G. herbaceum* (Uppam) alone. The parasitism of the isolate from the Nagpur material was tested on the bolls of some of the available types of cotton and the results are recorded in Table III.

TABLE III

*Parasitism *of the Nagpur isolate on bolls*

	Inoculated		Control	
	Unwounded	Wounded	Unwounded	Wounded
G. herbaceum—				
1 H_1 . . .	7/10	10/10	0/10	0/10
2 H 2919 . .	1/9	5/10	,,	,,
3 Dharwar II .	0/8	4/6	0/6	0/6
G. arboreum—				
1 K_1 . . .	0/10	0/10	0/10	0/10
2 Cocanadas 171 .	6/9	8/10	,,	,,
3 Roseum . .	0/10	8/10	,,	,,
4 Verum 434	,,	0/10	,,	,,
5 Nadam . .	,,	5/10	,,	,,
6 Cernuum . .	,,	No external sign of infection but lint discoloured in inoculated lock in 4/10	,,	,,
7 Abu Haneira .	0/8	4/8	,,	,,
8 Nanking White .	3/9	10/10	,,	,,
9 Arboreum Vedasanthur	0/5	2/5	0/5	0/5
G. hirsutum—				
Co 2 . . .	0/10	0/10	0/10	0/10

*The denominator gives the number of bolls used in the experiment and the numerator those that were infected.

The parasitism on the bolls is more restricted. All indigenous types are not attacked and wounded bolls are more readily infected than unwounded ones. The exotic type did not take infection.

Discussion

Colletotrichum indicum Dast. is capable of causing seedling blight of most of the cultivated indigenous cottons. Heavy casualties may be caused according to the severity of infection. Besides bringing about the death of seedlings, the germination of seeds is prevented and thus a number gaps result in the field. But the susceptible stage is limited to a short period and if the seedlings can escape infection for four weeks no further damage is possible. This disease resembles to a large extent the American anthracnose of cotton. The spread of infection is also on similar lines. The fungus may be present inside the seed-coat of some seeds and this is quite possible because the bolls are infected. Besides this, the spores that may be present on the surface are also capable of infecting seedlings. The fungus may persist in the soil and help in the continuance of the disease. *Colletotrichum indicum* is capable of causing spots on the leaves of *Aristolochia bracteata*, and this plant is a common weed in black cotton soils. The ability of this fungus to parasitise bolls is restricted to some of the indigenous types belonging to *G. herbaceum* and *G. arboreum* groups.

Susceptibility to this fungus is confined to the indigenous (Asiatic) species and varieties of cotton. The American types are not infected. This is interesting, especially since the latter are themselves subject to anthracnose caused by *Glomerella gossypii*. This immunity is probably due to their different genetic constitution. The hybrid between *arboreum* and *barbadense* back-crossed to *barbadense* showed about 22 per cent susceptibility, proving thereby that the non-infection of seedlings of American type is due to the difference in the genetic make up. The cultivated Asiatic types are very susceptible, but the wild type shows a certain degree of resistance. Among the American types both the cultivated types having 52 chromosomes and the wild ones with 26 chromosomes ($2n$) do not get infected. Several indigenous types appear to be resistant to the boll-rot phase of the disease. Wounded bolls more readily take infection in the susceptible varieties, and in nature it is quite a common feature to note insect punctures on the pericarp and these can serve as places of entry. The Nagpur isolate infects wounded *Capsicum* fruits under Coimbatore conditions.

To obviate the chances of confusion with the American 'anthracnose' of cotton it is proposed that the Indian disease be designated 'seedling blight and boll-rot', the name adopted by Sundararaman [1926], which is highly descriptive of the different phases of the disease. *Colletotrichum indicum* belongs to the falcate-spored group of the genus while the conidial form of *G. gossypii* is cylindrical and hence the two parasites are entirely different.

I am greatly indebted to Mr K. M. Thomas, Government Mycologist, for help and sustained interest in the work. My thanks are also due to Rao Bahadur V. Ramanatha Ayyar, Cotton Specialist for kindly supplying the

seeds of different varieties of cotton and to Mr J. F. Dastur for readily sending diseased specimens of cotton bolls.

Summary

Colletotrichum indicum Dast. was isolated from diseased cotton bolls obtained from Nagpur. This isolate readily infects the seedlings of all the indigenous types of cotton experimented with. Seedlings over four weeks old are not infected. After five weeks even wound infections are not successful. Cultivated and wild American cotton seedlings are immune. A hybrid between Asiatic and American cottons exhibited partial susceptibility. Bolls of only some indigenous varieties are infected.

The fungus is capable of infecting leaves of *Aristolochia bracteata* and wounded fruits of *Capsicum annuum*.

Infection is both seed-borne and soil-borne. Penetration into the cotyledons is through stomata and epidermal cell. The base of the hypocotyl is entered through the epidermal cell. The hyphae spread in the beginning of infection mainly inter-cellularly but later become intra-cellular also.

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PARASITES OF THE INSECT PESTS OF SUGARCANE IN THE PUNJAB

BY

KHAN A. RAHMAN, B.Sc. (Edin.), Ph.D. (Cantab.), F.R.E.S.

Entomologist, Punjab Agricultural College, Lyallpur

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I. Introduction

SUGARCANE in the Punjab is attacked by a number of insect pests, the most important of which are the Pyralid moths, *Scirpophaga nivella* Fab., *Argyria sticticraspis* Hampsn., and *Chilo trypetes* Bisset and the Fulgorid bug, *Pyrilla perpusilla* Wlk. Between them they destroy about 35 per cent of the crop annually, but in a year of heavy outbreak each may be responsible for destroying 67 per cent of the crop. These pests are attacked by a number of insect parasites, observations on which were taken up as early as 1921 [Husain, 1921-1938]. Since 1934 these parasites have been under closer and more intensive study at four different centres in the Punjab, viz. Sonepat Gurdaspur, Jullundur and Lyallpur, each centre being representative of the soil and climatic conditions under which sugarcane is grown in the Punjab. The data collected during the course of these investigations is presented in this article.

II. Species of parasites

Order Hymenoptera

1. *Family Scelionidae*

Teleonomus (*Phanurus*) *beneficiens* Zehnt.

Distribution.—This parasite is widely distributed in the Punjab.

Insect hosts.—It parasitizes the eggs of *Scirpophaga nivella* Fab. So far, it has not been found on the eggs of any other insect host in the Punjab.

Bionomics.—The female parasite inserts her ovipositor, through the hairy covering of the egg-cluster, into an egg of the host insect and lays an egg therein. In captivity, a female parasite laid a total of 20 eggs in different egg-clusters of the host insect. The parasitized egg always turns black in colour. Table I gives the percentage of parasitization of *Scirpophaga nivella* Fab. eggs during February-October at Jullundur.

It is seen from Table I that *T. beneficiens* Zehnt. is most active in April and in August-October when it completes its life-cycle in 10-12 days. During May-July, when the temperature in shade is 117°F. and humidity 14 per cent, it becomes scarce. Its activities during November-January, when the insect host is present only as a hibernating caterpillar, have not been ascertained so far.

TABLE I

Percentage of parasitization of S. nivella *Fab. eggs by* T. beneficiens *Zehnt. at Jullundur*

Month	Number of host eggs examined	Number of host eggs found parasitized	Percentage parasitization
February .	830	148	17·8
March .	961	181	19·9
April .	339	173	51·0
May .	1,385	24	1·7
June .	439	*Nil*	*Nil*
July .	1,606	53	3·3
August .	1,821	848	46·6
September	27	14	52·0
October .	1,401	961	68·6

2. *Family Chalcididae*

Trichogramma 2 spp.

Distribution.—These parasites are common throughout the Punjab.

Insect hosts.—Two species of *Trichogramma* (not yet specifically identified) have been bred out in the Punjab from the eggs of *Argyria sticticraspis* Hampsn., *Chilo zonellus* Swinh., *Sesamia uniformis* Dudgn., and *Emmalocera depresella* Swinh.

Bionomics.—*Trichogramma* spp. are active during March-October. The period of their greatest abundance, however, is September-October, when in certain years they may parasitize 90 per cent of the host eggs. One of these two species of *Trichogramma* completes its life-cycle in the eggs of *Argyria* in about six days at 90°-98°F.

Elasmus zehntneri Ferr.

Distribution.—This parasite has so far been reported from Jullundur, Lyallpur and Sonepat.

Insect host.—It parasitizes only the full-grown larvae of *Scirpophaga nivella* Fab.

Bionomics.—*E. zehntneri* Ferr. is most active during July-February. The female selects a mature caterpillar for oviposition, stings it into a state of torpidity and lays its eggs in a cluster besides it. On hatching, the parasite larvae feed on the body juices of the paralysed host caterpillar, and when full-fed, they pupate in the tunnel (in which the host caterpillar was feeding in the stem of sugarcane) without cocoons.

Rhaconotus scirpophagae Wilksn.

Distribution.—This parasite is common at Lyallpur, but rare at Jullundur and Sonepat.

Insect hosts.—It attacks the larvae of *Scirpophaga nivella* Fab., *Emmalocera depresella* Swinh. and *Chilo trypetes* Bisset.

Bionomics.—It is active during October-March when it parasitizes 1-2 per cent of the hibernating host larvae, particularly those of *Scirpophaga nivella* Fab.

Goryphus sp.

Distribution.—This parasite is common at Jullundur, Lyallpur and Sonepat and rare at Gurdaspur.

Insect hosts.—It attacks the larvae of *Scirpophaga nivella* Feb. and *Chilo trypetes* Bisset.

Bionomics.—It is active during July-February : in 1934-35 and 1935-36 it parasitized respectively 13 and 3·2 per cent of the larvae of *Scirpophaga* during this period at Jullundur.

Stenobracon (*Glyptomorpha*) *desae* Cam.

Distribution.—It is common at Lyallpur and Sonepat but rare at Jullundur. It has also been recorded at Jhelum.

Insect hosts.—It parasitizes the larvae of *Scirpophaga nivella* Fab., *Argyria sticticraspis* Hampsn., *Chilo trypetes* Bisset, *Emmalocera depresella* Swinh. and *Chilo zonellus*, and the pupae of *Scirpophaga nivella* Fab.

Bionomics.—It is active from July to September.

Harmoniae sp.

Distribution.—It is common at Gurdaspur and Lyallpur but rare at Jullundur.

Insect hosts.—It parasitizes the larvae of *Scirpophaga nivella* Fab. and *Schaenobius bipunctifer* Wlk. (Rice borer : Pyralidae : Lepidoptera).

Bionomics.—It is active from September to February.

Chelonus sp.

Distribution.—This parasite has so far been collected from Sargodha only.

Insect hosts.—It parasitizes the larvae of *Scirpophaga nivella* F. and *Emmalocera depresella* Swinh.

Bionomics.—It was collected from the larvae of *Scripophaga* in October and from those of *Emmalocera* in April.

3. *Family Encyrtidae*

Ooencyrtus papilionus Ashm.

Distribution.—This parasite is uniformly distributed in the Punjab.

Insect host.—It is a very important egg parasite of *Pyrilla perpusilla* Wlk.

Bionomics.—The parasite is scarce during April-June. It becomes active in July, but it reaches its peak during the period from September to December when, along with *Tetrastichus pyrillae* Craw., it may parasitize 79 per cent, with an average of 30 to 40 per cent, of *Pyrilla* eggs. There is considerable reduction in its numbers during January-March, when it is found in sugarcane trash.

The life-cycle of the parasite is completed in 10-64 days depending upon the season as is clear from Table II. The female lives for about five days during April-October and about 24 days during the cold weather. The highest number of eggs laid by a female in confinement was 30.

TABLE II

Duration of the life-cycle of Ooencyrtus papilionus *Ashm. at Lyallpur*

Date of oviposition by the adult parasite	Date of emergence of the adult parasite	Duration of life-cycle (in days)
21 Aug.	31 Aug.	10
4 Oct.	20 Oct.	16
3 Nov.	28 Nov. to 2 Dec. . . .	25—29
23 Nov.	26 Jan.	64

Ascogaster sp.

Distribution.—It has so far been collected from Lyallpur only.

Insect host.—It parasitizes the larvae of *Emmalocera depressella* Swinh.

Bionomics.—The bionomics of this parasite has not been studied so far. It was found active in June.

Dipterous tachinida

Distribution.—It occurs at Lyallpur but is rare.

Insect hosts.—It parasitizes the caterpillars of *Sesamia uniformis* Dudgn.

Bionomics.—It was collected in July.

4. Family Eulophidae

Tetrastichus pyrillae Craw.

Distribution.—This parasite is widely distributed in the Punjab.

Insect host.—It parasitizes the eggs of *Pyrilla perpusilla* Wlk.

Bionomics.—*T. pyrillae* Craw. is active throughout the year. Its life-cycle is completed in 11-23 days, depending upon the season, as is seen from Table III.

TABLE III

Duration of life-cycle of Tetrastichus pyrillae *Craw.*

Date of oviposition by the adult parasite	Date of emergence of the adult parasite	Duration of life-cycle (in days)
23 April	5 May	12
24 April	5 May	11
28 Sept.	9 Oct.	11
19 Oct.	5 Nov.	17
8 Nov.	1 Dec.	23

Seasonal abundance of the egg parasites of Pyrilla perpusilla *Wlk.*—Observations on the yearly fluctuation in the population of *Pyrilla* egg parasites were made during 1926-34 at Lyallpur and the results are given in Table IV.

TABLE IV

Yearly fluctuation in the population (expressed as percentage of parasitization) of Pyrilla *egg parasites* (O. papilionus *Ashm. and* T. pyrillae *Craw.) at Lyallpur*

Year	July	August	September	October	November	December
1926	5·7	13·9	49·3	40·9	29·7	5·8
1928	14·3	29·0	36·5	32·2	27·6	25·0
1929	..	..	13·3	24·0	24·5	9·3
1930	..	..	26·0	38·0	33·0	12·2
1931	..	19·0	27·0	52·0	79·0	36·0
1933	..	..	71·5	77·9	51·2	20·8
1934	..	28·0	46·0	47·6	42·0	..

It is seen from Table IV that the *Pyrilla* egg parasites are most active during September-November when they may parasitize 71·5 to 79 per cent of the host eggs. Table V gives the percentage of parasitization of *Pyrilla* eggs by *O. papilionus* and *T. pyrillae* Craw.

TABLE V

Percentage parasitization by the two Pyrilla *egg parasites during July-December*

Month and year	Number of eggs examined	Number of host eggs found parasitized	Parasitization percentage
July—			
1928 .	929	132	14·2
1932 .	838	254	30·4
1935 .	1,913	2	0·1
August—			
1934 .	453	127	28
1935 .	2,926	1	0·03
September—			
1932 .	5,133	2,062	40
1933 .	2,012	1,439	71·5
1934 .	3,545	1,588	44·8
1935 .	5,021	2,065	41

TABLE V—*contd.*

Month and year	Number of eggs examined	Number of host eggs found parasitized	Parasitization percentage
October—			
1932 .	2,811	1,405	50
1933 .	1,094	853	78·0
1934 .	256	119	46·4
1935 .	13,060	1,593	12·2
November—			
1932 .	3,507	2,454	70
1933 .	737	376	51·0
1934 .	256	119	46·4
1935 .	13,060	1,593	12·2
December—			
1932 .	875	429	49
1933 .	891	186	20·8
1935 .	29,443	5,257	17·9

Both these parasites are not very active during April-June and again during January-March when the percentage of parasitization is very low indeed ; of the 58,472 and 2,937,173 eggs examined during these two periods only 0·004 and 0·0006 per cent respectively were found parasitized by these two parasites.

The intensity of attack on the eggs of *Pyrilla* by the two parasites, *O. papilionus* Ashm. and *T. pyrillae* Craw., depends upon the location of the host eggs : the eggs laid exposed on the leaves are much more heavily parasitized (up to 77·9 per cent) than those laid hidden in between the leaf-sheath and the cane stem which never have more than 5 per cent parasitization.

Efficiency of Pyrilla *egg parasites in the fields.*—In order to study the efficiency of *Pyrilla* egg parasites the sugarcane crop growing in two separate blocks at the Sugarcane Research Station, Jullundur, was selected in 1935-36. The two selected blocks were about 550 ft. apart. In the beginning of August 1935, only 2 per cent of the *Pyrilla* egg-clusters were found parasitized in them.

In one block encouragement of the egg parasites was taken up while the other block was kept as control. In the treated block (about 2 acres) about 2,900 parasitized egg-clusters were placed in parasite-hibernating cages (specially designed for the purpose) which were distributed over the entire block.

Parasitization was at par (2 per cent) in both the blocks to begin with. During the fourth week of August, however, parasitization increased to 55 per cent in the block where parasites were encouraged but it was only 9 per cent in the control block.

5. *Family Drynidae*

Lestrodrynius pyrillae Kieff.

Distribution.—It has been recorded at Gurdaspur, Jullundur, Lyallpur and Sonepat.

Insect host.—It attacks the nymphs of *Pyrilla perpusilla* Wlk.

Bionomics.—This parasite remains active throughout the year excepting during the period from January to mid-March when it is mostly present as pupae. Its extent of parasitization depends upon the age of the host nymphs : first stage nymphs are usually not much parasitized, but second and fifth stage nymphs are comparatively more, while the third and fourth stage nymphs are most heavily parasitized.

A female parasite lays up to 42 eggs. Its life-cycle occupies 37-157 days as is clear from Table VI.

TABLE VI

Duration of life-cycle of L. pyrillae *Kieff.*

Date of oviposition by the female parasite	Date of emergence of the adult parasite	Duration of life-cycle (in days)
18 April	25 May	37
27 Aug.	3 Oct.	37
27 Oct.	2 April	157
29 Nov.	6 April	128
8 Dec.	10 April	123

The percentage of parasitization by this parasite was studied during 1930-36 when more than 42·5 thousands of nymphs were examined. (Each parasitized nymph was found to have 1-3 Drynid sacs.) The results for January-June 1931 and July-December 1930 only are presented in Table VII.

TABLE VII

Percentage of parasitization of the nymphs of Pyrilla *by* L. pyrillae *during different months of the year*

Time of the year	Locality	Percentage parasitization of *Pyrilla* nymphs
January	Jullundur	0·2
	Lyallpur	1·2
February	Jullundur	0·2
	Lyallpur	0·3
March	Jullundur	0·2
	Lyallpur	0·2

TABLE VII—*contd.*

Time of the year	Locality	Percentage parasitization of *Pyrilla* nymphs
April . . .	Jullundur .	0·2
	Lyallpur .	0·2
May . .	Jullundur .	0·2
	Lyallpur .	0·6
June . .	Jullundur .	0·2
	Lyallpur .	3·5
July . .	Jullundur .	1·5
	Lyallpur .	1·5
August . .	Jullundur .	1·6
	Lyallpur .	0·8
September .	Jullundur .	1·9
	Lyallpur .	2·1
October . .	Jullundur .	2·5
	Lyallpur .	3·2
November .	Jullundur .	3·1
	Lyallpur .	3·1
December .	Jullundur .	0·5
	Lyallpur .	0·2

It is seen from Table VII that though the parasite is present throughout the year, it is abundant during September-November only.

L. pyrillae Kieff. is hyperparasitized by *Cheiloneurus* sp. (Fam. Encyrtidae) which is usually active during November-March.

ORDER STREPSIPTERA

Pyrilloxenos compactus Pierce

Distribution.—This parasite was recorded in the Punjab for the first time in 1928. Subsequently it was found to be fairly abundant throughout the sugarcane-growing areas of the Punjab and has been actually collected from Gurdaspur, Jullundur, Lyallpur and Sonepat.

Insect hosts.—It parasitizes the nymphs and adults of *Pyrilla perpusilla* Wlk., but shows a decided preference for the adults.

Bionomics.—It is a parasite of sporadic occurrence. During the period (1928 to date) it has been under study it occurred in abundance in 1934 at Lyallpur and in 1935 at Sonepat while in other years it was scarce throughout the province.

The parasite remains active throughout the year. Table VIII gives the duration of the life-cycle of the male.

TABLE VIII

Duration of the life-cycle of the male P. compactus *Pierce*

Triungulinid hibernated in host	Adult male emerged	Duration of life-cycle (in days)
16 May	27-29 June	42—44
27 Sept.	5 Nov.	39

The parasite has about five generations in a year as follows: February, May, May-July, July-September, September-November, November-February.

Table IX gives the percentage of parasitization in 1934 at Lyallpur and in 1935 at Sonepat.

TABLE IX

Percentage of parasitization of P. perpusilla *adults and nymphs by* P. compactus *Pierce*

(Total number of nymphs examined—1977; total number of adults examined—791)

Period		Locality	Nymphs	Adults
May	1934	Lyallpur	..	28·9
June	,,	,,	14·2	..
July	,,	,,	71·0	18
August	,,	,,	18—32	11·49
November	,,	,,	9	22
December	,,	,,	0·5	7
February	1935	Sonepat	11	10
March	,,	,,	88	50
April	,,	,,	86	37
May	,,	,,	10	37
June	,,	,,	12	66
July	,,	,,	35	..
August-November 1935		,,	0·07—2·6	1·1—2·3

III. Summary

The insect pests of sugarcane in the Punjab are attacked by about 14 different kinds of parasites which have been under observation since 1921. Of these parasites the following require special mention.

Teleonomus beneficiens Zehnt.: This is a widely distributed parasite of the eggs of *Scirpophaga nivella* Fab. This parasite is most active in April and in August-October, when it parasitizes 5 and 45-68·5 per cent of the host eggs respectively.

Trichogramma spp. parasitize the eggs of *Argyria sticticraspis* Hmpsn., *Chilo zonellus* Swinh., *Sesamia uniformis* Dudgn. and *Emmalocera depressella* Swinh. These parasites are active during March-October when, in certain years, they may parasitize 90 per cent of the host eggs.

Ooencyrtus papilionus Ashm. and *Tetrastichus pyrillae* Craw. are the very important egg parasites of *Pyrilla perpusilla* Wlk. which are widely distributed in the Punjab. These parasites are most active during September-November when they may parasitize 71·5 to 79·0 per cent of the host eggs.

Other parasites are discussed under distribution, insect hosts and bionomics in this paper.

REFERENCES

Husain, M. A. (1921-38). *Ann. Repts. Ent. Govt. Punjab, Lyallpur* (for each year from 1921 to 1938)

Rahman, Khan A. and Ram Nath (1940). *Bull. Ent. Res.* (*London*) **31**, Part 2

PLANT QUARANTINE NOTIFICATIONS

INDIA

Notification No. F. 30-7/37, dated June 7, 1940

IN exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Central Government is pleased to direct that the following further amendments shall be made in the Order published with the notification of the Government of India in the Department of Education, Health and Lands, No. F. 320/35-A., dated the 20th July 1936, namely :—

I. In the said Order—

(*i*) (*a*) paragraph 5 shall be re-numbered as sub-paragraph (1) of that paragraph ; (*b*) in that paragraph as so re-numbered, the words ' in the form prescribed in the Third Schedule ' shall be omitted ; (*c*) to that paragraph as so re-numbered the following sub-paragraph shall be added, namely :—

' (2) The certificate shall be in the form prescribed in the Third Schedule or in a form as near thereto as may be and supplying all the information called for in that form '.

(*ii*) in paragraph 7 for the words ' *Fomes semitostus* ' the words ' *Fomes lignosus* ' shall be substituted, and for the words ' *Fusicladium macrosporum* ' the words ' *Dothidella ulei* (=*Melanopsammopsis ulei*=*Fusicladium macrosporum*) ' shall be substituted,

(*iii*) in paragraph 8A for the words ' the *Mal de Secco Deuterophoma tracheiphila* ' the words ' *Mal Secco* caused by *Deuterophoma tracheiphila* ' shall be substituted,

(*iv*) in sub-paragraph (2) of paragraph 9 for the word ' aleurodes ' the word ' white-flies ' shall be substituted and for the words ' *Theilaviopsis paradoxa* ' the words ' *Ceratostomella paradoxa* or *Theilaviopsis paradoxa* ' shall be substituted.

II. In the Schedules annexed to the said Order—

(*i*) for the First Schedule the following Schedule shall be substituted, namely :—

' *FIRST SCHEDULE* [Paragraph 1 (*i*)]

Rule 5—General health certificate
Rule 6 (*b*)—Potatoes
Rule 7—Rubber plants
Rule 8A—Lemon plants and other citrus plants
Rule 8B—Unmanufactured tobacco
Rule 9—Sugarcane, etc.

Paragraph 1	Country of origin 2	Authority 3
5, 6 (*b*), 7, 8A & B and 9	Angola . . .	The Director, Laboratory of Plant Pathology and Agricultural Entomology, Directorate of Agricultural and Commercial Services, LUANDA
	Argentine . .	The Ministry of Agriculture

Paragraph 1	Country of origin 2	Authority 3
5, 6 (*b*), 7, 8A & B and 9—*contd.*	Australia . .	Chief Quarantine Officer for Plants
	Belgian Congo .	The Department of Agriculture, Industry and Commerce
	Belgium . .	The Department of Agriculture (Phytopathological Service)
	Bermuda . .	The Department of Agriculture
	Brazil . . .	Service de Vigilancia Sanitaria Begetal
	British Guiana .	The Department of Science and Agriculture
	British Honduras .	The Department of Agriculture
	Burma . . .	The Department of Agriculture
	Canada . . .	Dominion Department of Agriculture
	Ceylon . . .	The Department of Agriculture
	China . . .	Plant Quarantine Service, Ministry of Economic Affairs, Chungking, SZECHWAN
	Cyprus . . .	The Department of Agriculture
	Denmark . .	The Ministry of Agriculture
	Dutch Indies . .	The Department of Agriculture, Industries and Commerce
	Egypt . . .	The Ministry of Agriculture
	Eire . . .	The Department of Agriculture
	France . . .	The Ministry of Agriculture
	Gambia . .	The Department of Agriculture
	Germany . .	The Department of Agriculture
	Gold Coast . .	The Department of Agriculture
	Great Britain and Northern Ireland	The Ministry of Agriculture and Fisheries, England The Ministry of Agriculture, Northern Ireland The Department of Agriculture, Scotland
	Greece . . .	The Ministry of Agriculture

Paragraph 1	Country of origin 2	Authority 3
5, 6 (*b*), 7, 8A & B and 9—*contd.*	Holland . .	The Department of Agriculture
	Hong Kong . .	The Superintendent of Botanical and Forestry Department
	Hungary . .	Kingdom of Hungary Official Phytosanitary Service (Magyar Kiralysag Hivatalos Novenyegeszsegugyi Szolgalat)
	Iraq . . .	The Director of Agriculture, Baghdad
	Italy . . .	The Ministry of Agriculture
	Jamaica . .	The Director, Department of Science and Agriculture, Kingston, Jamaica
	Japan (including Formosa)	The Ministry of Agriculture and Forestry
	Kenya Colony .	The Department of Agriculture
	Malaya Peninsula .	The Department of Agriculture, Straits Settlements and Federated Malay States
	Malta . . .	The Department of Agriculture
	Mauritius . .	The Department of Agriculture
	Mozambique . .	Chief, Division of Entomology Technical Service for Agriculture, Lourenco Marques
	New Zealand . .	The Department of Agriculture, Wellington
	Nigeria . . .	The Department of Agriculture
	Norway . .	The Norwegian Board of Agriculture
	Nyasaland . .	The Department of Agriculture
	Palestine . .	The Department of Agriculture and Fisheries
	Philippine Islands .	The Bureau of Agriculture
	Portugal (including Azores and Madeira)*	The Chief Plant Pathologist, Department of Phytopathological Services, Ministry of Agriculture, Portugal

* The Phytopathological Services in Azores and Madeira are under the personal supervision of the Chief Plant Pathologist. Fumigation Chambers are available in Madeira at which plants may be fumigated on request of exporters. When there is doubt as to the health of plant exports, the material is sent from Azores and Madeira to the Chief Plant Pathologist for inspection and, if feasilble, certification.

Paragraph 1	Country of origin 2	Authority 3
5, 6 (*b*), 7, 8A & B and 9—*contd.*	Rhodesia (Northern)	The Director of Agriculture, Mazabuka
	Rhodesia (Southern)	The Secretary for Agriculture and Lands, Salisbury
	Sierra Leone . .	The Department of Agriculture
	South Africa . .	The Union of South Africa, Department of Agriculture
	Spain . . .	Phytopathological Inspection Service appointed by the Director-General of Agriculture
	Straits Settlements	The Director of Agriculture or Director of Gardens
	Sweden . .	The Ministry of Agriculture
	Tanganyika . .	The Department of Agriculture
	Trinidad and Tobago	The Department of Agriculture
	Uganda Protectorate	The Department of Agriculture
	United States of America	The Department of Agriculture
	Windward and Leeward Islands	Advisory Department of Agriculture at the Imperial College of Tropical Agriculture, Trinidad
	Zanzibar . .	The Department of Agriculture
	**Other countries*	
	Algeria . . .	The Ministry or Department of Agriculture of the countries concerned
	Bulgaria . .	
	Costa Rica . .	
	Eritrea . .	
	Estonia . .	
	Finland . .	

* When a Customs Officer receives a certificate required by the rules from any country not specified by name in any part of the schedule which relates to such certificate, he shall after passing the consignment forward the certificate to the Government of India, Education, Health and Lands Department, for information.

Paragraph 1	Country of origin 2	Authority 3
5, 6 (b), 7, 8A & B and 9—*contd.*	French Equatorial Africa	The Ministry or Department of Agriculture of the countries concerned
	French West Africa	
	Indo-China . .	
	Iran . . .	
	Italian Somaliland .	
	Lithuania . .	
	Luxemburg . .	
	Mexico . . .	
	Morocco . .	
	Switzerland . .	
	Tunis . . .	
	Turkey . . .	
	Union of Soviet Socialist Republics	
	Uruguay . .	
	Yugoslavia . .	

Additional authorities empowered to certify against the diseases specified in paragraphs 6 (b), 7, 8A & B and 9

7	Burma . . .	Mr L. P. Khanna, M.Sc., Lecturer in Biology, University College, Rangoon
8A . . .	Burma . . .	Mr L. P. Khanna, M.Sc., Lecturer in Biology, University College, Rangoon
	Italy . . .	Royal Italian Phytopathological Institute
	Rhodesia (Northern)	The Department of Agriculture
	Rhodesia (Southern)	The Department of Agriculture

Paragraph 1	Country of origin 2	Authority 3
Additional authorities empowered to certify against the diseases specified in paragraphs 6 (b), 7, 8A & B and 9—contd.		
9	Australia (Queensland)	Department of Agriculture and Stock
	Burma . . .	Mr L. P. Khanna, M.Sc., Lecturer in Biology, University College, Rangoon
	Jamaica . .	The Department of Science and Agriculture
	West Indies . .	The Imperial College of Tropical Agriculture, St Augustine, Trinidad

(*ii*) in the form of Certificate set forth in the Third Schedule for the words and brackets ' the plant(s), living plant(s) or plant products ' the following shall be substituted, namely :—

' the plant(s), living plant(s) or plant products ______________

a representative sample of the plant(s), living plant(s) or plant products '.

Notification No. F. 43-20/40-A., dated July 17, 1940

IN exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Central Government is pleased to direct that the following further amendment shall be made in the Order published with the Government of India, Department of Education, Health and Lands, Notification No. F. 320/35-A., dated the 20th July 1936, namely :—

In the second proviso to paragraph 4 of the said Order for the letters and words ' Dr L. S. Doraswami ' and ' Dr Doraswami ' the letters and words ' Mr H. C. Javaraya ' and ' Mr Javaraya ' shall be substituted respectively.

Notification No. F. 43-15/40-A., dated August 14, 1940

IN exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Central Government is pleased to direct that the following further amendment shall be made in the Order published with the notification of the Government of India in the Department of Education, Health and Lands, No. F. 320/35-A., dated the 20th July 1936, namely :—

In paragraph 8B of the said Order, after the words ' British India ', the words ' except from Burma ' shall be inserted.

Notification No. 46-29/38-A., dated October 9, 1940

IN exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Central Government is pleased to direct that the following further amendment shall be made in the Order published with the notification of the Government of India in the Department of Education, Health and Lands, No. F. 320/35-A., dated the 20th July 1936, namely :—

In clause (*iii*) of paragraph 1 of the said Order, for the word ' Rangoon ' the words ' Port Blair ' shall be substituted.

FOREIGN PLANT QUARANTINE REGULATIONS

United States of America

The following plant quarantine regulations and import restrictions have been received in the Imperial Council of Agricultural Research. Those interested are advised to apply to the Secretary, Imperial Council of Agricultural Research. New Delhi, for loan.

List of United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, Service Regulatory Announcements

1. *Quarantine and other official announcements*—
   (*i*) Fruit and vegetable quarantine—modification of regulations
   (*ii*) Pink bollworm quarantine—Administrative instructions
   (*iii*) Coffee quarantine—Notice of Quarantine No. 73 on account of coffee pests
2. *Summaries of plant quarantine import restrictions*
   Republic of Paraguay-Curculio added to List of Declared Pests
3. *Service and Regulatory announcements*
   October-December 1939

THE

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